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8725 John J. Kingman Road, MS 6201
Fort Belvoir, VA 22060-6201

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TECHNICAL REPORT

Smart Building Volume 2: System Description

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Charles Allen, et al.

Prepared by:
Northrop Grumman Corporation
Defense Enterprise Solutions
6940 South Kings Highway
Alexandria, VA 22310

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13. ABSTRACT (Maximum 200 words)

The Defense Threat Reduction Agency conducted a technology demonstration called "Smart Building" Program in support of the 2002 Winter Olympics. It showed that a facility could be protected from chemical and biological warfare agents, and radiological particulates using commercial-off-the-shelf-hardware. The facility selected was the Social Hall Plaza building in Salt Lake City, Utah. The key elements of the Smart Building system were infrastructure protection and consequence management.

The infrastructure protection team developed a comprehensive, automated, modular, transportable CBR protection system, developed a comprehensive automated modular, transportable CBR protection system and integrated it into Social Hall Plaza. The system provided positive pressure collective protection, chemical, biological and radiological detectors, automated HVAC response, notification procedures, emergency decontamination provisions, and physical security to regulate vehicle and pedestrian traffic.

The consequence management team provided the capability to assess the potential or actual impact of a threat event through the use of hazard modeling software tools at a Consequence Assessment Center, using the E-Team [R] incident management system. Developing the CAC involved the use of Geo-spatial information System, population database development and the linking of the Olympic Coordination Center to first responders, and remote sites to the incident management system.

Volume 2 provides detailed system descriptions for each functional area of the Smart Building Program. This includes the Threat and Vulnerability Assessment, Filtration System, HVAC System, CBR Detection System, Electrical Distribution System, Emergency Power System, Physical Security, Decontamination Operations and the Control System. This volume also provides a brief overview of the decommissioning effort associated with both the infrastructure protection team and the consequence management team. Lessons learned during the development and operation of the systems are identified.

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CONVERSION TABLE

Conversion Factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY ⟶ BY ⟶ TO GET
TO GET ⟵ BY ⟵ DIVIDE

angstrom	1.000 000 x E -10	meters (m)
atmosphere (normal)	1.013 25 x E +2	kilo pascal (kPa)
bar	1.000 000 x E +2	kilo pascal (kPa)
barn	1.000 000 x E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 x E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical/cm^2)	4.184 000 x E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 x E +1	*giga bacquerel (GBq)
degree (angle)	1.745 329 x E -2	radian (rad)
degree Fahrenheit	$t_k = (t^o f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 x E -19	joule (J)
erg	1.000 000 x E -7	joule (J)
erg/second	1.000 000 x E -7	watt (W)
foot	3.048 000 x E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 x E -3	meter^3 (m^3)
inch	2.540 000 x E -2	meter (m)
jerk	1.000 000 x E +9	joule (J)
joule/kilogram (J/kg) radiation dose absorbed	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 x E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 x E +3	kilo pascal (kPa)
ktap	1.000 000 x E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 x E -6	meter (m)
mil	2.540 000 x E -5	meter (m)
mile (international)	1.609 344 x E +3	meter (m)
ounce	2.834 952 x E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 x E -1	newton-meter (N-m)
pound-force/inch	1.751 268 x E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 x E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 x E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 x E -2	kilogram-meter^2 (kg-m^2)
pound-mass/foot^3	1.601 846 x E +1	kilogram-meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 x E -2	**Gray (Gy)
roentgen	2.579 760 x E -4	coulomb/kilogram (C/kg)
shake	1.000 000 x E -8	second (s)
slug	1.459 390 x E +1	kilogram (kg)
torr (mm Hg, 0^0 C)	1.333 22 x E -1	kilo pascal (kPa)

*The bacquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (GY) is the SI unit of absorbed radiation.

ACKNOWLEDEMENTS

The authors would like to acknowledge the contributions of Messrs. Robert Kehlet and Richard Lewis, DTRA for their management and technical guidance and support throughout the Smart Building program.

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Volume 2 -System Descriptions

Introduction

The Smart Building Program was initiated by the Defense Threat Reduction Agency (DTRA) in 1999 and managed by Mr. Robert Kehlet. The objective of the program was to develop a "Smart" Building that could automatically respond to a Chemical, Biological, Radiological (CBR) threat and thereby provide protection to occupants and other important assets. The Smart Building protection system was modular and transportable, and designed to be integrated into most building structures in a relatively short time frame. The Smart Building protection system, identified as " Ancile," included collective protection, detection, decontamination, and physical security systems. Defense Threat Reduction Agency (DTRA) demonstrated this technology at the 2002 Winter Olympic Games in Salt Lake City, Utah. The system was installed on a building known as Social Hall Plaza in downtown Salt Lake City (SLC). Social Hall Plaza had been selected to house the Federal Bureau of Investigation (FBI) Joint Operations Center (JOC) and the Utah Olympic Public Safety Command (UOPSC).

1.1 Purpose

The purpose of this volume is to describe the design of the overall protection system and to summarize the control room operational procedures implemented in the Smart Building.

1.2 Technical Approach

The first step in developing the integrated collective protection (CP) system was to perform and document a Threat and Vulnerability Assessment to fully characterize the issues associated with the release of a chemical or biological warfare agent or radiological particulate. Next, a comprehensive protection assessment was conducted to characterize the building and understand the requirements of the users. This assessment identified and evaluated an array of potential protection solutions and the cost/benefit associated with each.

Although the system had to be designed to provide an appropriate level of protection, it also needed to meet all applicable building codes and not interfere with the operations of the users. Numerous market surveys and evaluations were conducted to select the best components for the protection system. One key program guideline was to incorporate only proven commercial off-the-shelf (COTS) equipment into the system.

1.3 Building Protection System Overview

The Smart Building protection system was comprised of a complex array of components including a filtration system, a CBR detection system, a decontamination capability, emergency power system, and a control system. The system was designed to provide continuous protection to the FBI Operations Center and the UOPSC, which occupied approximately 30% of the building. Additionally, the protective system provided limited protection to floors 1-4 through the CBR Detection System and automated response capability.

The filtration system for the Smart Building was comprised of two modular CP filtration systems (MCPFS), each of which provided 10,000 cfm of filtered air into the protective envelope for a total of 20,000 cfm. This system was designed to meet military air transportation requirements and was designed into two standard military shipping containers (Mil-Vans). An auxiliary boiler system conditioned the air supplied by the filtration system to approximately 55°F. Once heated, the filtered air was mixed with the return air from the protective envelope in the fifth and sixth floor mechanical rooms. From there two Trane air handling units (AHU) located on each floor, installed in newly-constructed mechanical rooms, conditioned the air and distributed the conditioned air to the fifth and sixth floors.

The internal CBR detection system consisted of two types of chemical detectors, radiological detectors, and the Joint Biological Point Detection System (JBPDS). Four locations were identified for placement of the chemical detectors. Two of the locations identified were in the penthouse and contained a surface acoustic wave (SAW) detector and an ion mobility spectrometry (IMS) detector. One of the locations housed two IMS detectors in order to monitor for both chemical warfare agents and toxic industrial chemical (TIC) compounds at that location. A radiological detector was also placed in each of the two penthouse locations. The radiological detector was a sodium iodide (NaI) detector. The JBPDS was also installed in the penthouse mixing room in order to monitor all of the return and make-up air from outside the building.

The external CBR detection system consisted of five locations that were identified on buildings adjacent to Social Hall Plaza. Buildings were selected primarily by location, to surround the Smart Building at a distance that would provide sufficient warning time for the building ventilation system time to respond. Locations were sought that would be in line with the prevailing winds for the area. Priority was given to buildings managed by the same company as the Smart Building, for efficient access, security and control. Cost considerations limited the total number of exterior locations, so prioritization, based on the threat/vulnerability assessment, was essential. Four of the five buildings selected each housed one chemical and one radiological detector. The fifth building served as a satellite control room for the JBPDS operators and contained an external JBPDS on the roof of the building. The chemical and radiological detectors were intended to provide an advanced warning of a challenge in the immediate area. The JBPDS would not have been able to provide an advanced warning, but would have provided notification if a challenge involving a biological warfare agent had occurred. The first identification of this type of an event would have occurred approximately 15 to 20 minutes following the event provided the biological contaminant passed over the external detector. However, the final determination that an actual event had occurred would not have been made until several hours after the initial identification. A Gold Standard Laboratory at the Utah Department of Health would have provided the final determination on whether an actual event had occurred.

The control system integrated most of the components of the Smart Building into a single server. This server monitored the following components of the Smart Building Program:

- Filtration system sensors

- Internal CBR detectors
- External CBR detectors
- Differential Pressure sensors in the mantrap, airlock, and decontamination rooms
- Automated building response
- Meteorological tower
- Closed circuit television cameras

In addition to the main server located in the control room, several other computers were located in the control room to monitor the Staefa Building Management System (©Siemens Building Technologies AG / Ltd.) and allow control room operators to monitor, and if necessary confirm, that an automated building response had taken place. The E-Team software was also located in the control room and was the main software communication tool used to inform DTRA, FBI and UOPSC personnel that an incident was occurring and the emerging status of the resolution. The control system also incorporated the closed circuit television feeds that were received from cameras located both internal and external to the building. This video feed was displayed on four closed-circuit television screens located in the control room and was stored digitally for analysis later.

The control system would also initiate the automated building response based on an alarm from a chemical or radiological detector. The response of the ventilation system was based on initial building modeling that was performed and a detailed understanding of how the air flowed through the building. The automated building response following a positive identification of a biological agent would occur manually following notification from JBPDS personnel.

In order to respond to a possible CBR challenge on the building, decontamination rooms were built into the fifth and sixth floors to allow personnel to be processed into and out of the protective envelope. These rooms were designed to process one or two people at a time and utilize soap and water decontamination. Prior to entering the decontamination rooms all personnel entering the protective envelope following a challenge on the building would first have been decontaminated using a dry decontaminating powder. The decontaminating powder is part of a kit called Special Personnel Event Expedient Decontamination System (SPEEDS) that would have been deployed in the elevator lobby on the fifth floor. The sixth floor decontamination room was only to be activated as a last resort for processing personnel into the building.

Emergency power was also incorporated into the Smart Building Program. A 1000-kilowatt emergency generator on the third level of the parking garage provided enough power for continuous operation of the fifth floor, sixth floor, and the collective protection system in the event of a power outage. A 2000 gallon cement lined vaulted fuel tank supplied the emergency generator with enough fuel for 24 hours of sustained operations.

At the conclusion of the Olympic events, DTRA/Battelle removed the building protection equipment and restored the building to its prior condition. Disposition of materiel and restoration actions were coordinated with FBI officials and Zions Securities representatives.

1.4 Consequence Management Support System Overview

The Smart Building consequence management computer systems consisted of computer workstations, servers, and local area networks (LANs).

- On the fifth floor, over seventy IBM personal computers were installed. To maximize system resources, workstation software was limited to Microsoft Internet Explorer, Version 5.5 and Adobe Acrobat.
- On the sixth floor, approximately fifteen IBM personal computers were installed. Identical to the workstations on the fifth floor, workstation software was limited to Microsoft Internet Explorer, Version 5.5 and Adobe Acrobat.
- In the Smart Building, two Dell 6300 RAID servers were installed. They were primarily used for the E Team software; both were fully redundant, and were capable of supporting system operations should one of the servers fail or lose power.
- Outside the Smart Building, three Dell servers were installed in various locations within the Olympic Theater. All were fully redundant, and were capable of supporting system operations should one of the servers fail or lose power.
- Two separate fiber optic Ethernet 10/100 LANs were installed in the Smart Building:
    - On the fifth floor, over seventy workstations were connected to a LAN. The servers for this network were connected to the Utah State wide area network (WAN) through Cisco PIX firewalls.
    - On the sixth floor, over fifteen workstations that supported the FBI Intelligence Center were connected to a standalone E Team server. For security reasons, this was a standalone network with no external connections to the Utah State WAN.

At the conclusion of the Olympic events, DTRA/SAIC turned over the computers, servers, and user licenses to the State of Utah, and provided E Team and CATS training and planning support to Utah state and local agencies.

2.0 Threat and Vulnerability Assessment

A Threat and Vulnerability Assessment (TVA) was performed before beginning any building protection design activity. This assessment was documented and furnished to DTRA, but the document and the assessment were classified SECRET, and declassification authority was not received prior to the publication of this report.

2.1 Threat Types

The types of threats that might be employed by an adversary against the building were considered. The Federal Emergency Management Agency (FEMA) has defined specific CBR threat events[1], and these were used as a starting point.

2.1.1 Chemical Threat

Toxic industrial chemical and chemical warfare (CW) threats were considered, based on their availability, toxicity, and dispersal properties.

2.1.2 Biological Threat

Biological threats from bacteria, viruses and toxins were considered, based on factors such as activity, incubation period, virility, lethality, stability and transmissibility.

2.1.3 Radiological Threat

Radiological material may emit harmful alpha, beta, gamma or neutron radiation. These were assessed according to the relative degree of hazard they each present, and the availability of each potential threat.

2.1.4 Dissemination Methods

The potential CBR threats were further considered according to the dissemination methods that may be associated with them:

- Airborne external standoff release
- Airborne external proximate release
- Airborne internal release
- Waterborne release
- Foodborne release

2.1.5 Physical Assault Threat

The range of potential physical assaults upon the building, from mob violence to a terrorist truck bombing, was considered.

2.2 Threat Ranking

The potential threats were ranked in terms of likelihood, based on intelligence information and technical understanding of the nature of each type of threat[2].

---

[1] Blaylock, Neil W., Williamson, Eric B., Cox, P.A., Engineering Guidance for Mitigating the Effects of and Responding to a Terrorist Attack, Southwest Research Institute Report for the Army Corps of Engineers, March 31, 1998.

[2] Stuempfle, A.K., Howells, D.J., Armour, S.J., and Boulet, C.A., International Tsk Force 25: Hazard from Industrial Chemicals, Final Report, April 1998.

2.3 Vulnerability Assessment

After the potential threats were assessed, the vulnerability of the specific target was addressed. This assessment consisted of two phases: a broad area survey and an asset/facility assessment.

2.3.1 Broad Area Survey

The broad area survey evaluated the surrounding area, the external signature of the building, and all entrance/egress routes.

The surrounding area considered parks, parking lots, office buildings, parking garages, etc. All features were considered for cover, concealment, and unobstructed fields of view. Vulnerability is reduced by the presence of a secured standoff distance.

External signatures are indicators that may provide an adversary with critical information concerning activities inside. External signatures considered included:

- CBR filtration or detection equipment
- Meteorological stations
- Communication antennae
- Lighting that reveals hours of operation/occupancy
- Volume of personnel entering/exiting the building
- Special equipment visible during construction/installation

Entrance/egress routes provide a means for an adversary to readily gain access to the immediate area surrounding a facility. They include streets, roads, railroads, and airports, and they may provide efficient, unobserved access/escape from the vicinity of the facility.

2.3.2 Asset/Facility Assessment

This phase of the assessment considered the immediate area outside the building and any public access areas inside. It identified potential avenues of approach that may represent vulnerabilities. The following aspects of the assessment were addressed:

- Building occupancy and operations
- HVAC system
- Ease of access
- Single point failure
- Social engineering
- Internal signatures

2.4 TVA Lessons Learned

2.4.1 Prioritize the Threats and Vulnerabilities

Because the cost and complexity of protecting against all conceivable WMD threats would be excessive, it is better to design a protection system that is focused specifically to address the highest priority threats and most significant vulnerabilities

2.4.2 Location Creates Vulnerabilities

Selection and placement of the main command and control center in an urban environment for monitoring the Olympics resulted in special physical security needs that were addressed.

3.0 System Descriptions

3.1 Filtration System

3.1.1 Design

The Smart Building CP system, shown in Figure 1, was located on a support platform that was installed on the roof of Social Hall Plaza. The CP system consisted of two MCPFS units and an auxiliary boiler system. Each MCPFS included a Pre-Filter and Final-Filtration component (see Figure 2). The rack that supported this system was 60' long x 8' wide and contained specially installed web stiffeners to strengthen the I-beams and distribute the load to the columns. The MCPFS units were mounted on the two ends of the support platform. The boiler system was cantilevered off the west end of the platform.

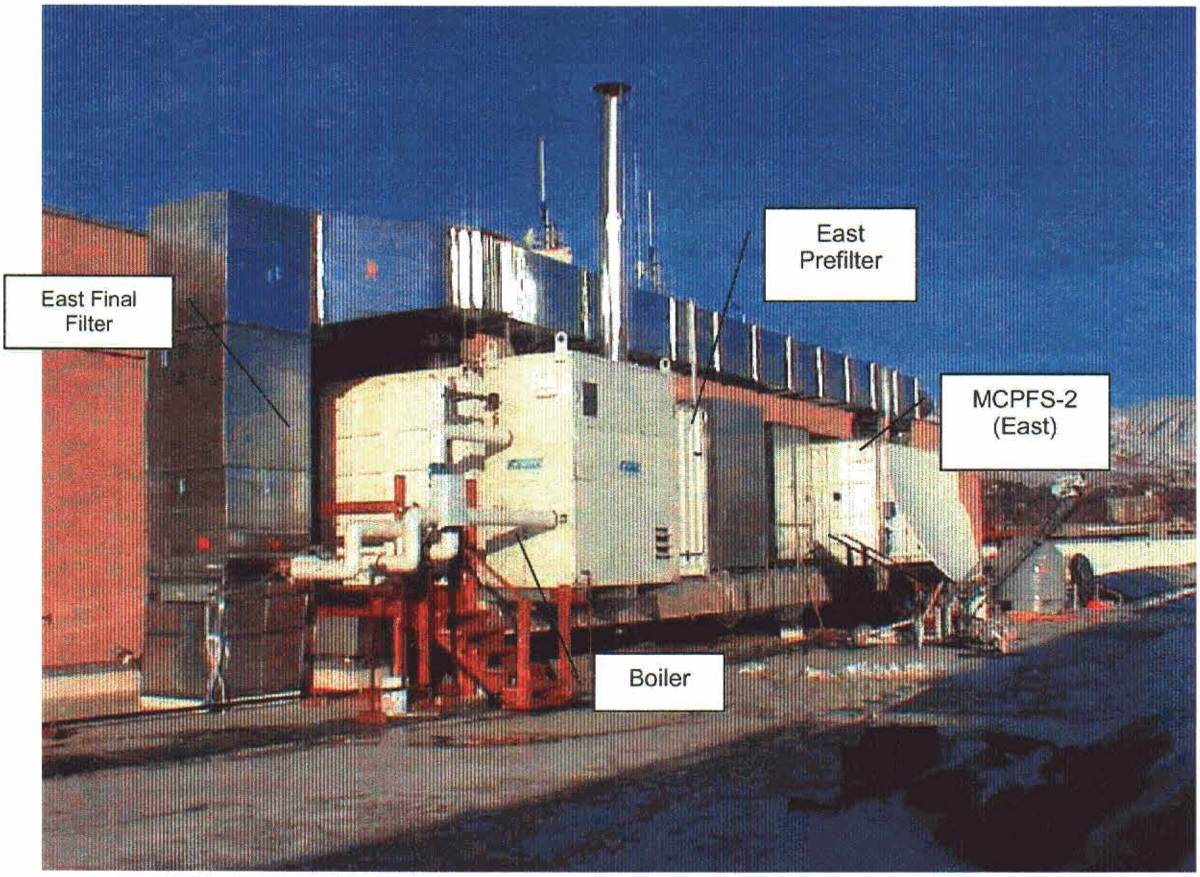

Figure 1. Smart Building Filtration System

The Pre-Filter component of the MCPFS, shown in Figure 2, housed 12 standard 20% efficiency filters (ASHRAE 52.1-Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter). These filters removed gross particulates from the air and extended the life of the M56A1 filters located in the Final Filter component. The Pre-Filter component was designed to hold an additional axial vane fan to accommodate a supplementary filtration system, which was being designed to filter specific TICs. The augmentation filtration system was being developed by Auburn University and employed a novel filtration media and filter units designed to be periodically cleaned and restored by heat-desorption. The development of the augmentation filtration system was not completed in time for it to be delivered to the Smart Building; however, it may be included in future applications of the Ancile system. The Pre-filter component (without the additional fan) weighed approximately 2000 lbs.

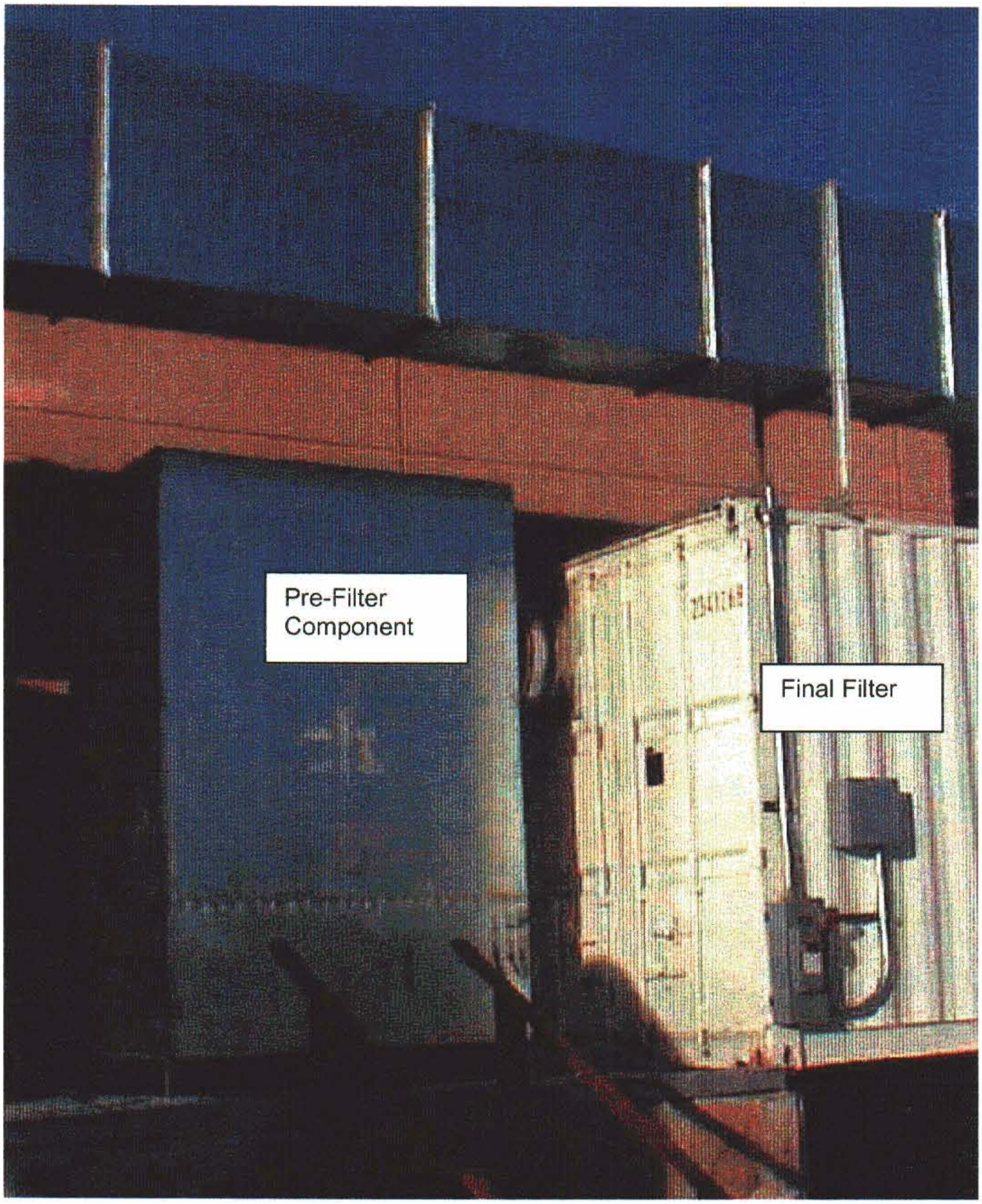

Figure 2. Components of the East MCPFS

The Final-Filter component, visible in Figure 3, included the majority of the components of the MCPFS. To satisfy the requirement for air-transportability, this component was housed within standard shipping containers commonly referred to as Mil-Vans or CONEX containers. These containers are nominally 20' long, 8' wide, and 8.5' tall. Inside the containers, the Final-Filtration system utilized a direct drive axial vane fan capable of providing at least 10,000 cfm of air at a static duct velocity of 10 iwg. The fan pulled outside air through the Pre-filter component and pushed it past a bank of 50 M56A1 filters (See Figure 4). The M56A1 filters were housed within FFA1000-200 filter housings manufactured by Hunter Protective Systems. Each FFA1000-200 held five M56A1 filters; therefore, each MCPFS consisted of ten FFA1000-200 units. The M56A1 filters are the military standard CP filter and consist of a HEPA and activated carbon filter. These filters are capable of protecting against most of the known military chemical and biological warfare agents and many toxic industrial chemicals. The Final-Filtration component weighed approximately 12,300 lbs.

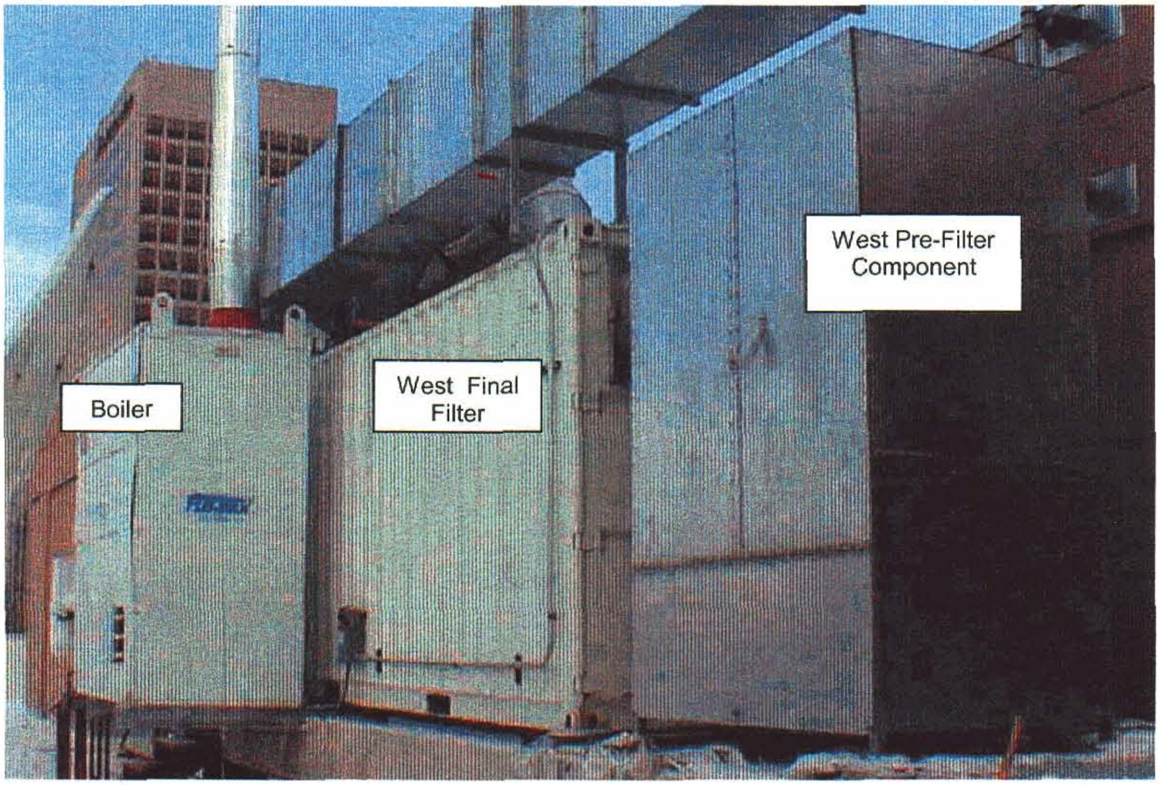

Figure 3. Components of the MCPFS

The Filtration System was designed to pressurize the protective envelope (fifth and sixth floors) to approximately 0.1 inches of water with respect to the outside environment. This over-pressurization provided protection from outside air infiltration for winds up to 15 MPH. As with normal building configurations, the 4th floor and other areas of the building were also slightly pressurized with respect to the outside environment. The filtered air required to provide the pressurization to the protective envelope entered the building from the roof through a filtered air supply shaft that delivered air directly into the fifth and sixth floor mechanical rooms. Within these mechanical rooms, the filtered outside air was mixed with return air from within the protective envelope. Once mixed, the air was conditioned and then distributed throughout the existing duct loop on the fifth and sixth floor ducting.

The boiler system was also modular and air transportable. The boiler system used natural gas to provide 1512 MBTUH in four firing stages. Figure 3 shows the boiler system as installed on the roof support platform. The boiler system pre-heated the filtered winter air (to approximately 55° F) to prevent the building heating system from being overcome by the increased volume of cold outside air.

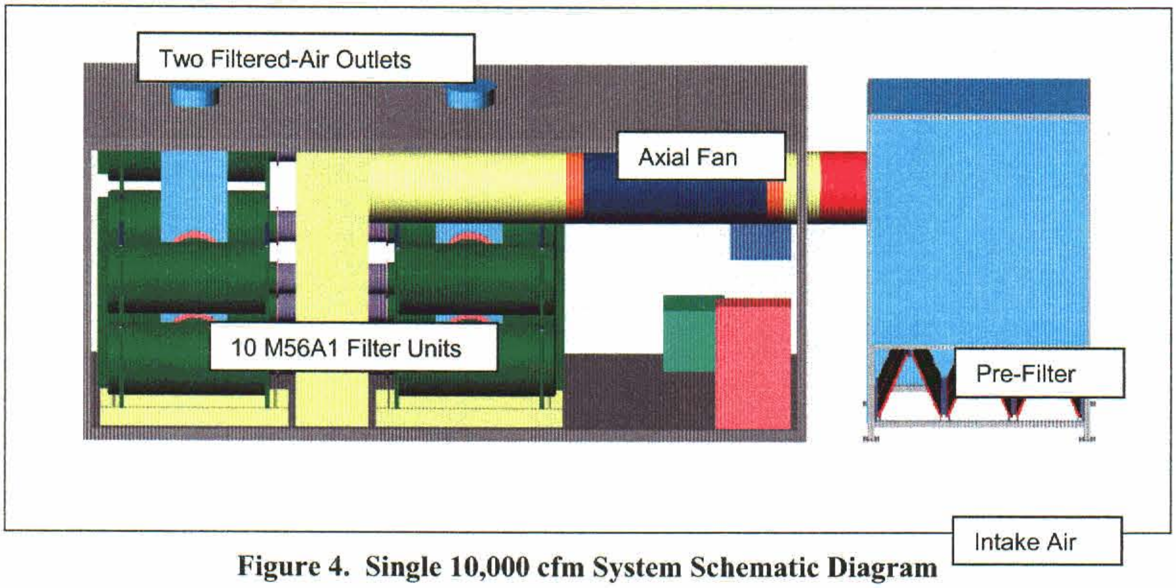

Figure 4. Single 10,000 cfm System Schematic Diagram

3.1.2 Filtration System Testing

Each subsystem was inspected, operated through its range of performance, and inspected again. Instrumentation was used to confirm that the subsystems filtered the necessary flow rate of air as designed, without exceeding structural, thermal, or electrical limits.

An endurance test of the filter subsystems was performed after successful completion of the system functioning test.

The pre-filters were removed from the Mil-Van units and the systems were operated at nominal airflow, 10,000 cfm. No excessive inlet restriction was detected. No distortion or leakage was detected.

Table 1. Summary of Endurance Test Results

Parameter	MCPFS, West Mil-Van, S/N 235988-4	MCPFS, East Mil-Van, S/N 234126-8	Specifications
Maximum temperature inside Mil-Van, at intake end	89.5°F	Not measured	N/A
Maximum temperature inside Mil-Van, at opposite end	Not measured	86.3°F	N/A
Maximum temperature in test building	86.3°F	86.3°F	N/A
Fan motor current, each wire (480V, 60Hz, 3-phase), maximum	19 Amp	20 Amp	60 Amp full

Parameter	MCPFS, West Mil-Van, S/N 235988-4	MCPFS, East Mil-Van, S/N 234126-8	Specifications
Fan motor current, average	17.7 Amp	18.3 Amp	32 Amp max.
Back pressure at maximum airflow	1.30 iwg	1.28 iwg	10.0 iwg, max.

No excessive fluctuations in temperature, motor current, or differential pressure were detected. All functional parameters remained within specification tolerances. Results are summarized in Table 1

The system was then installed at Social Hall. Both Mil-Vans, both pre-filters, the boiler, and all the associated ducting was assembled without incident. The system was started and operated continuously for several weeks at an airflow rate of 5000 cfm for each Mil-Van. The fans operated perfectly at this flow rate, with no fluctuations, vibrations, leaks, or other indications.

The motor speeds were increased, and the pressure drop of the overall system was recorded at unit airflow rates of 5,000, 8,000, 10,000 and 12,000 cfm

Leak testing was performed twice. First, the Mil-Vans were leak-tested at the factory. Then the leak tests were repeated after the Mil-Vans had been installed at Social Hall Plaza. Fan speeds were set to generate airflow of 10,000 cfm through each Mil-Van unit and the system was leak-tested in accordance with standard U.S. Army Soldier, Biological, Chemical Command (SBCCOM) filter leak test procedures. Both Mil-Van units met the SBCCOM standards for vapor and particulate efficiency. The leak test factory and installed system test results are summarized in Table 2 and Table 3, respectively. Note that "efficiency" is the reciprocal of "penetration."

Table 2. Filter Leak Test Results – Factory Tests

Parameter	Mil-Van 1		Mil-Van 2		Criteria
	Front Bank	Rear Bank	Front Bank	Rear Bank	
Particulate penetration	0.006%	0.008%	0.003%	0.003%	0.030%
Particulate efficiency	99.994%	99.992%	99.997%	99.997%	99.970%
Vapor penetration	<0.054%	<0.015%	<0.014%	<0.013%	0.100%
Vapor Efficiency	>99.946	>99.985	>99.986	>99.987	99.000%

Table 3. Filter Leak Test Results – System Installation Tests

Parameter	Mil-Van 1	Mil-Van 2	Criteria
Particulate penetration	0.004%	0.025%	0.030%
Particulate efficiency	99.996%	99.975%	99.970%
Vapor penetration	<0.012%	0.090%	0.100%
Vapor Efficiency	>99.988%	99.910%	99.900%

3.1.3 Filtration System Lessons Learned

3.1.3.1 Boiler System

Battelle had intended to utilize the existing building boiler system to heat the filtered air entering the building. However, the building owners objected to that idea based on the capacity of their boiler system. Therefore, the pre-heat boiler system had to be added to the roof support frame, making it less accessible than it should have been. Ideally, a boiler module should be an integral part of the MCPFS.

3.1.3.2 M56A1 Filter Unit Design

The M56A1 filter units were not specifically designed to be stacked the way they are in the Hunter filters used in the MCPFS, and the seals on the filters are compressed only slightly before the metal housings contact each other. It is likely that the overall system leakage, while within Army specifications, could be further improved by the addition of another seal in between each of the stacked M56A1 filter units.

3.1.3.3 Augmentation Filtration System

The M56A1 filter units were designed to remove all military chemical warfare agents. They will also remove many TICs, but there are still a number of harmful chemical vapors that terrorists may employ that are not removed by the M56A1 filters. In addition, it is conceivable that an extremely large quantity of threat vapor could result in eventual breakthrough, releasing some quantity of the vapor into the protective envelope. The completion of the augmentation filtration system with a filtration media designed to capture these additional threats would enhance the protection provided by the collective protection system.

3.1.3.4 Roof Construction

The building chosen for this project had a rubber membrane roof with an area of concrete only under the penthouse above the sixth floor. This type of construction is used to minimize weight and therefore cost for construction of the building, but it allows for a significant amount of leakage, especially when the building is pressurized.

Leakage points can include roof penetrations of any size and shape that are particularly difficult to seal because of the flexibility of the membrane and expansion and contraction with temperature. The rubber membrane is also easily punctured, and the addition of a multitude of antennas and other communications equipment did result in many additional holes that were not noticed until after the antennas were removed. In addition, on this type of non-ballasted roof, the membrane begins to lift up at approximately 0.1 iwg. This causes a greater air volume in the envelope as well as more leakage pathways. The lifting of the membrane can also compromise seals around roof penetrations.

Even though the initial costs of construction are higher, it is well worthwhile to use/construct a building with a concrete-capped roof to minimize air leakage. Cost savings are seen in the reduced size of the filtration system needed as well as in energy costs for heating and air-conditioning.

3.1.3.5 Filtration System Support Structure

The weight of the filtration system necessitated the addition of a steel support structure on the roof of the Smart Building. The design and fabrication took longer than expected, adding to the cost and risk associated with the program. In future applications, roof-mounted filtration systems will benefit from early integration of support structure requirements.

3.1.3.6 Air Shaft Sealing

Pressures on the fifth and sixth floor were changed by changes in relief fan settings. The majority of this fluctuation was due to increased leakage from the fifth floor to the fourth floor as the pressure decreased on floors 1-4. The leakage from the sixth floor to the penthouse through any penetrations also increased as the relief fan speed increased, again because of the lowered pressure in the penthouse. A third leakage pathway was the area around the return airshaft. Leakage paths around the return air dampers on the fifth and sixth floors may have been small, but the much lower pressure in the return air shaft caused small holes to have a larger airflow than the same size hole to the exterior of the building. The negative pressure of the return airshaft prevented infiltration of the envelope by unfiltered air; however taking steps to seal it would cause less loss of air and pressure from the envelope to the shaft, allowing higher envelope pressures to be achieved.

The positive pressure around the main building supply shaft was vented to avoid possible contamination of the envelope by unfiltered air at a higher pressure infiltrating the lower pressure of the envelope.

3.1.3.7 Selection of Engineering Contractors

The building owner selected the primary mechanical, electrical, and structural engineering contractors that would perform the detailed engineering associated with implementing the program. The electrical and structural contractors selected performed well to complete the necessary building modifications. The mechanical engineering contractor was not familiar with the additional requirements associated with infrastructure protection. This resulted in the construction contractor performing the mechanical work having to address issues that should have been identified in the design.

For future programs the contractor responsible for implementing the collective protection system should select the detailed engineering contractors.

3.1.3.8 Sealing the Protective Envelope

Due to the type of roof construction on the building there was excessive air leakage through the roof. Battelle had the construction contractor seal an opening in the wall construction that was believed to be allowing air from the sixth floor to leak out of the building due to the type of wall construction.

Additional inspections identified the roof membrane as another source of leakage that could be sealed to reduce the overall leakage from the protective envelope. Therefore, Battelle had the construction contractor seal the membrane on the roof where it passed over the parapet wall.

3.1.3.9 Sequence of Building Modifications

Due to the schedule, building modifications were still being performed around the control room after the furniture and computers were already installed and operational. The furniture and computers were protected as well as possible, but ideally the modifications (e.g., pulling electrical cables and installing control panels) would have been completed before the electronics were installed.

3.2 HVAC System

3.2.1 Design

The main components of the building heating, ventilation and air conditioning (HVAC) system were located in the penthouse. The maximum amount of air that could be exchanged throughout the building was approximately 176,000 cfm ±10 % at the supply fans. In the original building configuration, air was normally distributed throughout all six floors of the building through a common supply shaft that was located inside the penthouse. The common supply shaft had two openings per floor, both of which could be closed by removing the fusible link holding the fire damper open. The building was also constructed with a plenum air return system, which used the space above the drop ceiling as a means to draw the return air back to the return air shaft and up into the penthouse. The return airshaft drew air from the plenums on all six floors up to the penthouse through the large building exhaust fans.

In the penthouse, both the return air and make-up air were drawn through an array of 120 particulate filters 2 feet in length, 2 feet in width, and 4 inches in depth. The array was arranged in a rectangular pattern containing 20 columns and 6 rows to filter the air distributed throughout the building. Based upon the outside air temperature and weather conditions, the Staefa building management system regulated the amount of return and make-up air introduced into the building. Once the air passed through the filters, a series of cooling coils were utilized to cool the air, if necessary, prior to the air entering the main air supply shaft.

The building HVAC system was modified to prevent air that had not been filtered for chemical and biological warfare agents and TICs from entering the protective envelope (i.e., fifth and sixth floors). Therefore, sheet metal caps were installed in the fifth and sixth floor supply and return airshaft. The return airshaft was sealed off with a combination of sheet metal caps and low-leak dampers. The low-leak dampers were installed in order to enable the fifth and sixth floors to be flushed with filtered air following a breach of the protective envelope. The building exhaust fans would then be utilized to help draw the contaminant up the return airshaft and out of the building. When the fifth and sixth floor supply and return air ducts from the building ventilation system were sealed off, the building HVAC system only conditioned the air for floors 1 through 4, allowing it to operate at a lower overall flow rate.

With the CP system operational, the return air from the protective envelope was drawn into the mechanical rooms that were constructed on the fifth and sixth floors. The return air was mixed with the filtered air and distributed throughout the fifth and sixth floors, utilizing the existing ducting and variable air volume (VAV) boxes. This allowed the Staefa Building Management System to monitor the temperature within the various zones of the building and adjust the VAV boxes to provide additional cooling as required. The filtration system provided the required make-up air in order to comply with required air quality standards and pressurize the protective envelope (fifth and sixth floors).

Based on the selection of the fifth and sixth floors as the protective envelope and the application of the CP system, two Trane commercial self-contained air-handling units (AHU) were installed in the mechanical rooms on each floor. These units were placed in mechanical rooms, and they utilized water from the rooftop-cooling tower for cooling the air conditioning condenser. The return air for each floor was drawn through the back of the AHU, cooled, and then discharged vertically through the top of the system. The ducting from the AHU to the duct loop on the south side of the supply shaft was connected to the duct located in the plenum area directly above the west air-handling unit in each mechanical room. The ducting from the AHU to the duct loop on the north side of the supply shaft ran from within the mechanical rooms to the east and then turned north and connected to the high-pressure duct loop on the north side of the building.

The main high-pressure duct formed a continuous loop, and the Trane AHUs were connected in parallel. If one AHU were to break down, the other one would be run at a higher level to force the air through the entire duct loop. Static pressure and temperature sensors were added to the main high-pressure duct to provide the AHU the required information to allow the units to maintain the required supply air temperature and duct static pressure.

When the CP system was brought on-line, the building HVAC system was rebalanced to ensure the building HVAC system was functioning properly with fifth and sixth floors offline and only four floors operating on the building HVAC system. Existing building pressure sensors were also monitored to assess whether floors 1 through 4 were maintaining a slight overpressure as specified in the initial design of the building ventilation system.

3.2.2 HVAC System Testing

The building HVAC system was tested to verify that it automatically changed to the correct preset automated response configuration, both day and night, by introducing simulated alarms from each detector in the system. It was reset between tests to confirm the reset function. The preset automated response configurations could also be implemented manually from the sixth floor control room at any time, either before a detector alarm or after an automatic configuration change. These functions were also tested.

3.2.3 HVAC System Lessons Learned

The Trane AHUs on the fifth and sixth floor all shut down repeatedly because of clogged cooling tower water filters. The schedule for checking the cooling tower filter was adjusted to provide more frequent routine maintenance inspections to help prevent system shutdowns. Additionally, the service contractors responded immediately to diagnose and correct the problem in order to prevent that operations from being interrupted.

Air movements in the building were affected by elevator motion. Movement of the elevators would have had a direct impact on the transport of contaminants from the first floor lobby to the elevator lobbies located on higher floors. An elevator exhaust fan was installed at the top of the elevator shaft to prevent potentially contaminated airflow into the protective envelope from fifth and sixth floor elevator lobbies

3.3 CBR Detection System

The primary objective of the CBR detection system was to provide an early warning of the presence of TICs, chemical/biological warfare agents, and radiological materials in the proximity of the Smart Building. The CBR detection system consisted of detection equipment located both internal and external to the building. The suggested threats identified by FEMA for CBR events were defined as follows:

- Chemical – 1 to 2 liters of Sarin (GB).
- Biological – 100 grams of anthrax spores in a pressurized can with an aerosol valve.
- Radiological – 600 grams of Plutonium238 and 600 grams of Plutonium239 in a radiological dispersion device.

3.3.1 Examples of Actual CBR Releases

One of the worst incidents involved an airborne external standoff release of a TIC in Bhopal, India. In 1984, a disgruntled employee at a pesticide plant initiated an explosion in one of the storage tanks. This led to a massive release of methyl isocyanate in which the toxic fumes affected thousands of people living in the proximity of the plant. The State Government of Madhya Pradesh declared that there were 3,828 deaths and 203,509 persons injured.

One example of a food-borne release of a biological agent involved a 1984 incident in Dalles, Oregon. Saboteurs targeted the salad bars of 10 restaurants; the release affected 674 people. Salmonella typhimurium was confirmed as the bacterial agent.

The 1986 nuclear accident in Chernobyl serves as a prime example of the effects of radiological contamination by means of an airborne external standoff release following an accidental explosion at this facility. Over 100,000 people were evacuated. Over 600,000 were significantly exposed.

An example of an internal release of a chemical warfare agent involved a 1995 incident in Japan. The Aum Shinrikyo, a rebellious apocalyptic Japanese religious sect, released Sarin in the Tokyo, Japan subway. Plastic bags of Sarin were punctured and placed in the subway. The puddles of diluted Sarin were allowed to evaporate. Because of this Sarin attack, 12 people were killed and 5,000 people were directly affected.

In October 2001, the United States Post Office delivery system was sabotaged with a bacterial agent that included both a surface release and an internal release. Anthrax-laced letters were sent through the mail to several key individuals, such as Congressmen and Television News Broadcasters. As the letters were processed through the mail, a large number of personnel, equipment, and facilities were exposed by surface contact. The anthrax agent was made of very high-grade material; and it is believed that due to the way the letters were processed at the mail sorting facilities the agent was also released as an airborne hazard. Five people died as a result, many were infected, and tens of thousands took preventative medicine. It took from weeks to months for mail, equipment, and facilities to be restored in some of these facilities.

3.3.2 Chemical Detection

A covert chemical attack carried out by a terrorist organization could go undetected if symptoms and fatalities were not immediate and could result in large areas becoming contaminated. An undetected release of an airborne chemical inside the Smart Building would result in the rapid spread of the chemical throughout the building's ventilation system. A rapid detection of airborne chemical hazards is necessary for the Smart Building to respond with defensive measures to mitigate the hazard and limit the spread of the challenge. External airborne chemical threats also need to be detected. Detection of an external airborne chemical threat will allow the Smart Building protective measures to be initiated in order to minimize the infiltration into regions of the building that are not pressurized, and to secure the entry and exit portals to the protected area of the building.

A chemical attack on the Smart Building could involve the dispersal of either a Toxic Industrial Chemical (TIC) or a chemical warfare agent. TICs are widely present in developed countries and have been defined by International Task Force-25 (ITF-25) as chemicals that are produced in excess of 30 tons per year at a single facility and that pose a high degree of hazard. Hazards include high toxicity, corrosiveness, flammability, explosiveness, and reactivity. Because TICs are industrial commodities and by products used in almost every industrial process they are stored in large quantities and transported by truck, rail, and ship. Large quantities of TICS can be found at industrial storage sites, rail yards, shipyards, and along truck routes used for transportation.

An example of a common TIC is chlorine gas, which in the United States is produced in quantities exceeding 11 million tons per year. Many of the TICs pose a significant short-term hazard due to their corrosiveness, flammability, explosiveness, or reactivity with air or water. These hazards can be much greater than the immediate toxic effects obtained from a release of a TIC. Most TICs have both acute and chronic health effects. Acute effects can include skin irritation, choking, nausea, and dizziness, while chronic effects can include damage to the heart, lungs, liver, and other organs, as well as possible carcinogenic effects.

The ITF-25 identified potential TICs that may be deployed by a terrorist or military nation against U.S. interests. This study considered parameters such as the number of producers, availability, toxicity, and transportability. Ninety-eight TICs were identified by the study. These TICs were ranked as either being a High Hazard, Medium Hazard, or Low Hazard. A High Hazard ranking indicates a highly toxic and easily vaporized TIC that is widely produced, stored, and transported. A Medium Hazard ranking indicates a TIC that may rank high in some categories but lower in others such as number or producers, volatility, or toxicity. A Low Hazard ranking indicates that the TIC is not likely to be a hazard unless specific operational factors designate otherwise. A list of the high hazard TICs are shown in Table 4.

Table 4. High Hazard Toxic Industrial Chemicals

Ammonia	Ethylene oxide	Hydrogen sulfide
Arsine	Fluorine	Nitric acid, fuming
Boron trichloride	Formaldehyde	Phosgene
Boron trifluoride	Hydrogen bromide	Phosphorus trichloride
Carbon disulfide	Hydrogen chloride	Sulfur dioxide
Chlorine	Hydrogen cyanide	Sulfuric acid
Diborane	Hydrogen fluoride	Tungsten hexafluoride

Chemical warfare agents could also be deployed in an attack on the Smart Building. Chemical warfare agents are designed to kill or incapacitate enemy troops and are broken down into several categories characterized by their physiological effect. Nerve agents are the most toxic of the chemical warfare agents; death occurs rapidly after entry into the body. The two most effective routs of entry into the body are inhalation of the vapor and percutaneous adsorption from skin contact with either vapor or liquid. Common nerve agents include the G agents Tabun (GA), Sarin (GB), Soman (GD), GE, GF and the V agents VG, VM, and VX. Choking agents are not as toxic as nerve agents; they attack the lungs and cause death less rapidly. Common choking agents include phosgene, diphosgene, and chlorine. Blood agents interfere with oxygen binding to hemoglobin and can cause death rapidly at high concentrations. Common blood agents include arsine (AC) and cyanogen chloride (CK). Blister agents, or vesicants, are chemical agents that cause painful blistering of the skin. Their effect is often delayed 6 to 8 hours, however some of the vesicants cause pain and irritation on contact. As a result, exposures to low concentrations of the delayed acting vesicants may go unnoticed due to the lack of symptoms and odor resulting in a high dosage. Common vesicants are sulfur mustard (HD), nitrogen mustard (HNC), lewisite (L), and the arsenical vesicants.

The effectiveness of a TIC or chemical warfare agent as a terrorist weapon would be dependent upon factors such as method of dissemination, meteorological conditions, volatility, toxicity, and if it were dispensed within a building or outside.

A terrorist attack involving a TIC or chemical warfare agent would involve disseminating the chemical in one of the following states:

- Vapor
- Aerosol
- Liquid

TICs or chemical warfare agents could be delivered with almost any type of conventional weapon system and any number of improvised devises ranging in size from glass bottles to tanker trucks. Methods of delivery could include bombs, spray tanks, and aerosol generators. Temperature, wind speed, inversion conditions, and other meteorological factors also influence the duration of effectiveness of an external attack involving a TIC or chemical warfare agent. For example, as TICs and chemical warfare agents are exposed to the environment, they tend to be dispersed by the wind, which necessitates the use of large amounts of material to ensure that a given target receives a sufficiently high dose.

Volatility refers to the ability of a TIC or chemical warfare agent to vaporize at relatively low temperatures. Volatility is important because low volatility liquid agents will not evaporate quickly. For example, in order for a TIC or chemical warfare agent to be effectively distributed throughout a building's HVAC system, it must be vaporized or sprayed into a fine aerosol. Highly volatile agents are easily vaporized, whereas low volatile agents will persist for extended periods. Vapors, aerosols, and highly volatile liquids tend to disperse rapidly upon dissemination. This would aggravate the situation in an enclosed space, but it could help to reduce concentration levels sooner in a well-ventilated space.

Toxicity refers to the ability of a TIC or chemical warfare agent to produce damaging or lethal effects on an individual's health. The dose of a TIC or chemical warfare agent and thus the resulting toxic effect is dependent upon the time of exposure and the concentration of the toxic substance. The less time spent in a toxic environment, the lower the dose. The two dose measurements of importance are the LD50 and ID50. The LD50 is the dose at which 50 percent of the population exposed will experience lethal health effects (i.e., death). The ID50 is the dose at which 50 percent of the population will experience incapacitating health effects (i.e., severe injury or illness). Typically, volatile agents with moderate to high toxicity will cause the greatest concern.

To detect the occurrence of a chemical attack on the Smart Building multiple detectors were selected and were used in tandem. Detector technologies were selected such that the technological weakness of one was a strength of another. For instance if a certain detector technology was known to give false G agent alarms in the presence diesel fumes it would be used in tandem with a detector technology that had a low occurrence of false alarming in the presence of diesel fumes. This would allow for more accurate detection and identification of false alarms due to chemical interference as the various technologies would provide independent confirmation of the other detector's alarms. Detectors were selected based on the results of a detailed market study and the specific requirements of this program. Two kinds of chemical detectors were selected: the CW Sentry Plus from Microsensors, Inc. and the RAID-1 from Bruker Daltonics. The RAID-1 Chemical Detector utilizes IMS technology while the CW Sentry Plus utilizes SAW and electrochemical technology. These instruments continuously monitored the building air and the air external to the building to identify the presence of a chemical challenge initiated anywhere inside or external to the building.

3.3.3 CW Sentry Plus

The CW Sentry Plus is a dual technology detection system that contains two detection cells. The first cell employs three SAW sensors to detect chemical warfare agents and the second employs four electrochemical cells to detect a variety of TICs and certain chemical warfare agents. The airborne threats that can be detected by the SAW sensors and the electrochemical sensors are provided in Table 5 along with their detection limits. The CW Sentry Plus has two operational modes: Fast Mode (FM) and Slow Mode (SM). In the fast mode, samples of air are drawn into each of the two detection cells and a rapid analysis (total of 20 seconds) is performed. In the slow mode, air is drawn into each of the two detection cells over a longer time frame (total 120 seconds) and a more accurate analysis is performed.

The SAW sensors consist of a polymer coated piezo-electric crystal. Each of these crystals has a natural resonance frequency that is related to the mass of the polymer coating. When exposed to organic chemical vapors the polymers will adsorb some of the vapor, swell, and increase in mass. This change in the mass of the polymer film is detected as a change in the resonance frequency of the piezo electric crystal. For the detection of organic chemical warfare agents, polymer coatings are selected that preferentially absorb different classes of chemicals. As a result of the polymer coating selection, when the three piezos are exposed to an organic chemical warfare agent each polymer film will adsorb a different mass. The ratio of the adsorbed masses is used to uniquely identify HD, HDN, and the G and V nerve agents as a class. After each sampling, the SAW cell is heated and purged with air to evaporate any organics that may have been absorbed by the polymer film.

The second detector cell contains four electrochemical cells that are used to detect those agents and TICs that can't be detected by the SAW sensors. Each of the electrochemical cells contains two electrodes and an aqueous electrolyte solution. One end of the cell has a hydrophilic (repels water) membrane in contact with the electrolyte. The membrane allows the TICs and chemical warfare agents shown in Table 5 to diffuse from the air stream sampled by the detectors and then be pumped into the electrolyte solution. Each of the four electrochemical cells is held at a different potential which will result in an electrical current if the absolute value of the reduction potential of the substance sampled from the air stream is less than the potential difference of the cell. By looking at the relative amplitudes of any resulting currents developed in each of the 4 electrochemical cells the identity and concentration, if present, of the TICs and chemical warfare agents given in Table 5 can be determined.

Table 5. Chemicals and Detection Thresholds for the Detectors

Detector Cell	Alarm Code	Chemical Detected	Sensitivity Fast Mode /Slow Mode	Median Lethal Dose, (LD50), (mg-min/m^3)
SAW	H	Sulfur Mustard/Nitrogen Mustard 3	0.4 / 0.09 mg/m^3	900-1500 inhaled, 1400-10,000 by skin
SAW	G	G and V agents	0.1 to 0.9 / 0.02 to 0.25 mg/m^3	15-70 inhaled, 150-15,000 by skin
Electrochemical	BloD	Hydrogen Cyanide, HCN	5.0 ppm	Varies widely
Electrochemical	CHOK	Phosgene, $COCl_2$	0.3 ppm	3200
Electrochemical	ACId	Sulfur Dioxide, SO_2	1.5 ppm	
Electrochemical	HALO	Chlorine, Cl_2	2.5 ppm	
Electrochemical	HALO	Bromine, Br_2	4.0 ppm	
Electrochemical	HALO	Nitrogen Dioxide, NO_2	5.0 ppm	
Electrochemical	HYdR	Arsine, AsH_3	0.4 ppm	5000
Electrochemical	HYdR	Diborane, B_2H_6	3.0 ppm	
Electrochemical	HYdR	Hydrogen Sulfide, H_2S	3.0 ppm	
Electrochemical	HYdR	Hydrogen Cyanide, HCN	10.0 ppm	

The output from the CW Sentry Plus that was transmitted to the control room consisted of an alphanumeric data stream with 10 entries. An example of a data stream output for the SAW cell and what the values represent is shown in Table 6. The data output for the SAW detection cell is output every 20 seconds in the fast mode and every 120 seconds in the slow mode. The electrochemical cell only outputs data when there is a change in what is being detected or a positive chemical warfare agent or TIC signal when first turned on. Table 7 shows the possible Alarm codes for each of the detection cells. The definitions of the Status codes for the detector are given in Table 8.

Table 6. Data Output Stream for the CW Sentry Plus

SAW Cell Data Output										
Sample Output	1534	1/14/02	HI G	FM	69	80	111	33	OK	1444
Definition	Time	Date	Alarm	Mode	SAW1	SAW2	SAW3	Temp	Status	Unit
Electrochemical Cell Data Output										
Sample Output	1534	1/14/02	HI BLD	FM	0	0	0	33	OK	1444
Definition	Time	Date	Alarm	Mode	NA	NA	NA	Temp	Status	Unit

Table 7. CW Sentry Plus and HAZMATCAD Plus Alarm Codes

Detector Cell	Chemical	Alarm Code	Concentration Range	
SAW	G and V Agents	HI G	GA, GD	> 1.50 mg/m^3
			GB	> 4.50 mg/m^3
			GF	> 0.50 mg/m^3
			VX	> 0.05
		MED G	GA, GD	0.60 to 1.50 mg/m^3
			GB	1.80 to 4.50 mg/m^3
			GF	0.20 to 0.50 mg/m^3
			VX	0.02 to 0.05 mg/m^3
		LOW G	GA, GD	0.30 to 0.60 mg/m^3
			GB	0.90 to 1.80 mg/m^3
			GF	0.10 to 0.20 mg/m^3
			VX	0.01 to 0.02 mg/m^3
	Sulfur and Nitrogen Mustards	HI H	> 2.0 mg/m^3	
		MED H	0.8 to 2.0 mg/m^3	
		LO H	0.4 to 0.8 mg/m^3	
Electrochemical	Hydrogen Cyanide HCN	Hi BL	> 25.0 ppm	
		MED BL	10.0 to 25.0 ppm	
		LO BL	5.0 to 10.0 ppm	
	Phosgene $COCL_2$	HI CHOK	> 1.5 ppm	
		MED CHOK	0.6 to 1.5 ppm	
		LO CHOK	0.3 to 0.6 ppm	
	Sulfur Dioxide SO_2	HI ACI	> 7.5 ppm	
		MED ACI	3.0 to 7.5 ppm	
		LO ACI	1.5 to 3.0 ppm	
	Fluorine F_2 Chlorine Cl_2 Bromine Br_2 Iodine I_2	HI HALO	Cl_2	> 12.5 ppm
			Br_2	> 20.0 ppm
		MED HALO	Cl_2	5.0 to 12.5 ppm
			Br_2	8.0 to 20.0 ppm
		LO HALO	Cl_2	2.5 to 5.0 ppm
			Br_2	4.0 to 8.0 ppm
	Hydrogen Cyanide HCN	HI HYR	> 50.0 ppm	
		MED HYR	20.0 to 50 ppm	
		LO HYR	10.0 to 20.0 ppm	
	Arsine AsH_3 Diborane B_2H_6 Hydrogen Sulfide H_2S	HI HYR	B_2H_6, H_2S	> 15.0 ppm
			AsH_3	> 2.0 ppm
		MED HYR	B_2H_6, H_2S	6.0 to 15.0 ppm
			AsH_3	0.8 to 2.0 ppm
		LO HYR	B_2H_6, H_2S	3.0 to 6.0 ppm
			AsH_3	0.4 to 0.8 ppm

Table 8. CW Sentry Plus and HAZMATCAD Plus Status Codes

Status Code	Definition
OK	No Faults
S1	SAW 1 Failure
S2	SAW 2 Failure
S3	SAW 3 Failure
CONC	Concentrator Failure
PUMP	Pump Failure
XCHEM	Electrochemical Failure

3.3.4 Rapid Alarm and Identification Device-1 (RAID-1)

The RAID-1 detector uses IMS to identify chemical warfare agents and TICs and calculate their concentration in the air. This technology exposes a sample of air to an ionizing radiation source. If the air contains organic vapors a fraction of the molecules will be ionized (develop an electric charge either positive or negative) and may also fragment or break into smaller components. The number of fragments formed if any, their mass, and the charge developed from this exposure is characteristic of the molecule.

After ionization, a sample of the gas is allowed to enter what is called a drift tube. In the drift tube, a DC electrical field is applied to accelerate the ions towards an ion detector. The polarity of the DC is changed to test for positive or negative ions. The time that it takes each of the ions to travel the length of the drift tube and impact on the detector is characteristic of the mass to charge ratio and the structure of the ion. As the collection of ionized fragments travel down the tube, they will separate according to their drift velocity such that the fragments with lowest mass to charge ratio impact the detector first creating a signal or peak. The amplitude of the peak is related to the number of fragments of that mass to charge ratio formed. By plotting detector output verses drift time a spectrum is created. The relative size and location of the peaks in the spectrum is characteristic of the compounds in the samples. By looking at the overall magnitude of the peaks, the concentration of the air born species can be determined.

The RAID-1 is able to detect a variety of chemical warfare agents and TICs; however, due to similarities in the location of the peaks in the spectrums it cannot identify all of the chemical warfare agents (CWA) and TICs in one mode. A second mode is required in order to prevent false identification of one compound as a similar compound. As a result two RAID-1s were employed at the outside air intake for the Smart Building to allow both chemical warfare agents and TICs to be detected and identified simultaneously. The chemical warfare agents and TICs that the RAID-1 can detect and the detection sensitivity are shown in Table 9. The response time for detection of chemical warfare agents and TICs ranges from 5 to 30 seconds.

Table 9. Chemical Warfare Agents and TICs Detected by the RAID-1

Chemical Detected	Mode*	Display Symbol	Sensitivity
VX	CWA	VX	0.04 mg/m^3
VX-thiole	CWA	VX	--
Soman	CWA	GD	0.08 mg/m^3
Sarin	CWA	GB	0.08 mg/m^3

Chemical Detected	Mode*	Display Symbol	Sensitivity
Tabun	CWA	GA	0.08 mg/m^3
Sulfur Mustard	CWA	HD	0.5 mg/m^3
Nitrogen Mustard	CWA	HN	--
Alpha-Lewisite	CWA	L	0.5 mg/m^3
Beta-Lewisite	CWA	L	0.5 mg/m^3
Gamma-Lewisite	CWA	L	0.5 mg/m^3
Lewisite Mixtures	CWA	L	0.5 mg/m^3
Prussic Acid	CWA	AC	--
Ammonia	ITOX	NH_3	0.7 mg/m^3
Chlorine	ITOX	CL_2	3 mg/m^3
Chloride (hydrolyzed)	ITOX	CLX	15 mg/m^3
Prussic Acid	ITOX	HCN	--
Sulfur Dioxide	ITOX	SO_2	0.4 mg/m^3

* CWA = Chemical Warfare Agent mode
* ITOX = Industrial Toxin or TIC mode

3.3.5 Biological Detection

Biological agents are living microorganisms that have the capacity to cause debilitating disease or death in man, animals, or plants. Biological agents are classified into three major categories: bacteria, viruses, and toxins. Bacteria are single-celled organisms that cause disease by either invading body tissues or releasing toxins that have detrimental effects on hosts, such as humans, plants, and animals. Examples of bacterial agents are anthrax, brucellosis, tularemia, and plague. Viruses are small organisms, which consist of genetic material that require living cells to replicate. They produce diseases that generally do not respond to antibiotics. Smallpox, ebola, and yellow fever are examples of viral agents. Toxins are poisonous substances made by living organisms that produce adverse effects in humans or animals. Examples of toxins are botulinum toxin, ricin, and staphylococcal enterotoxin B (SEB).

The effectiveness of a biological agent is dependent upon factors such as activity, incubation period, virility, lethality, stability, and transmissibility. The activity is a measurement of the percent of live microorganisms present in the dispersed material. The incubation period is the time between exposure and the appearance of symptoms. Virility refers to the ability of a microorganism to establish itself in a host species. Pathogens with high virility cause disease with relatively few organisms, while those with low virility require a large number of organisms to cause disease. Lethality is the ease at which an agent causes death. Stability is the length of time the organism or toxin will remain effective in a particular environment. Transmissibility refers to the ability of an infectious agent to spread from a source to a host.

Biological agents will cause the greatest number of casualties with the smallest amount of contaminant. For example, it would take eight grams of anthrax spores compared to 5,000 grams of radioactive material and 800,000 grams of nerve gas to produce the same number of deaths within a square mile. However, many difficulties must be overcome to disseminate the lethal doses that are required to produce mass casualties. One of the major obstacles is acquiring a biological agent of sufficient virulence and activity to produce mass casualties. Airborne viral agents, in particular, are extremely difficult to work with since the mass production, packaging, and storage of viruses is a very complicated task that demands advanced skill.

Aerosolization of biological agents also presents some major technical challenges. Biological agents can be aerosolized either in mud-like liquid ("slurry") form or in a dried, talcum powder-like form. Slurries tend to settle at the bottom of a container and clog the sprayer or aerosol dissemination device. Slurries are also difficult to disseminate as an aerosol of particles of an optimal size. Disseminating particles of the proper size (1 to 5 microns) is critical to the success of a mass casualty attack. Powders tend to cling to surfaces, thus making the agent difficult to handle and more probable that those handling it will accidentally infect themselves.

As biological agents are aerosolized and become airborne, they tend to rapidly decay. Sunlight, smog, humidity, and temperature reduce the abilities of pathogens to survive and multiply. However, biological agents dispersed in an enclosed space may not be subjected to conditions as adverse as the outdoor environment.

3.3.5.1 Joint Biological Point Detection System

The JBPDS consists of four major subsystems. These are the detector/trigger, collector, fluid transfer system, and identifier. The detector/trigger section utilizes the Biological Aerosol Warning Sensor -3 (BAWS-3). The BAWS-3 utilizes fluorescent-based technology to detect biological aerosol clouds from dirt and the overall background. The BAWS detects changes in the background and processes several channels of data to determine if aerosol particles are of biological origin. The BAWS continuously draws in air at 80-90 liters/min to detect any changes. When the BAWS detects a change in the background, which is in the biological area of interest, it triggers the rest of the system to begin collecting and processing a sample for identification. After a trigger, the collector is turned on and draws in air at 800 liters/min to collect a larger sample of the background air. The collector is a wetted wall cyclone collector, which impinges aerosol particles into a liquid suspension for analysis. This collection cycle is five minutes in length. The fluid transfer system (FTS) is an automated assembly, which moves all fluid within the system. After the first minute of collection, the FTS moves approximately 1 ml of the collected liquid to the identifier for an identification process. The identifier utilizes antibody based assay strips for identification. The identifier automatically injects this 1 ml sample of liquid into the assay strips. The assay strips are contained within a carrier assembly, which holds up to ten different assay strips and provides the ability to simultaneously identify up to ten different agents. This identifier design uses the basic hand held assay approach, but at a fully automated level. After the identifier reads the injected strips, it reports the results back to the operator and stores the data. Upon a positive identification, the FTS moves the remaining 4 ml sample of liquid to an independent vial for preservation, evacuation from the JBPDS, and further analysis. If the collected sample returns a negative identification for the ten agents, the 4 ml sample is delivered to a common sample container if needed later. The main computer within the JBPDS is the JBPDS Controller Assembly, which controls the entire operation of the system, as well as, data management. The JBPDS also has an integrated Global Positioning System (GPS) to provide accurate position and time data, a TACMET Met system to provide accurate Met data, and a Telemetry link for remote operation.

Figure 5 shows a picture of the JBPDS.

Figure 5. Joint Biological Point Detection System

The JBPDS uses a standard PC to control operation of the system. This can be done both locally at the system and remotely with an external connection. Intuitive operator controls provide the operator with real time updates of system operation, as well as, the ability to change modes of operation and overall data management (including component status and a bio event log). The JBPDS is capable of operation in several modes (standby, standard, periodic, single sample, and extreme cold weather). Once powered, the system goes through a start up procedure, which tests all components and ensures proper operation. After start up is complete, the system will alert the operator and remain in standby until the operator commands the JBPDS to another mode of operation. In standby, main power is applied but the components inside are not powered. The system may be placed in this mode at various times to allow the operator to check inside the system and replenish consumables.

The JBPDS consumables are the carrier assembly, a standard buffer collection solution, deionized water, and detergent. The carrier assembly is a plastic housing, which contains up to ten different agent assay strips. These carriers are housed within the

Identifier assembly and inoculated with the liquid sample generated within the system. After a fifteen (15) minute incubation period, the Identifier reads the carrier to determine the presence of the ten different agents. The buffer solution is used to impinge the collected aerosol particles and create a liquid suspension for analysis. The deionized water is used to rinse the internal fluid lines as the system is operated and the detergent is used to clean the fluid lines during shutdown. Figure 6 shows the JBPDS main screen. This screen is the main operator interface, which shows system status and overall control.

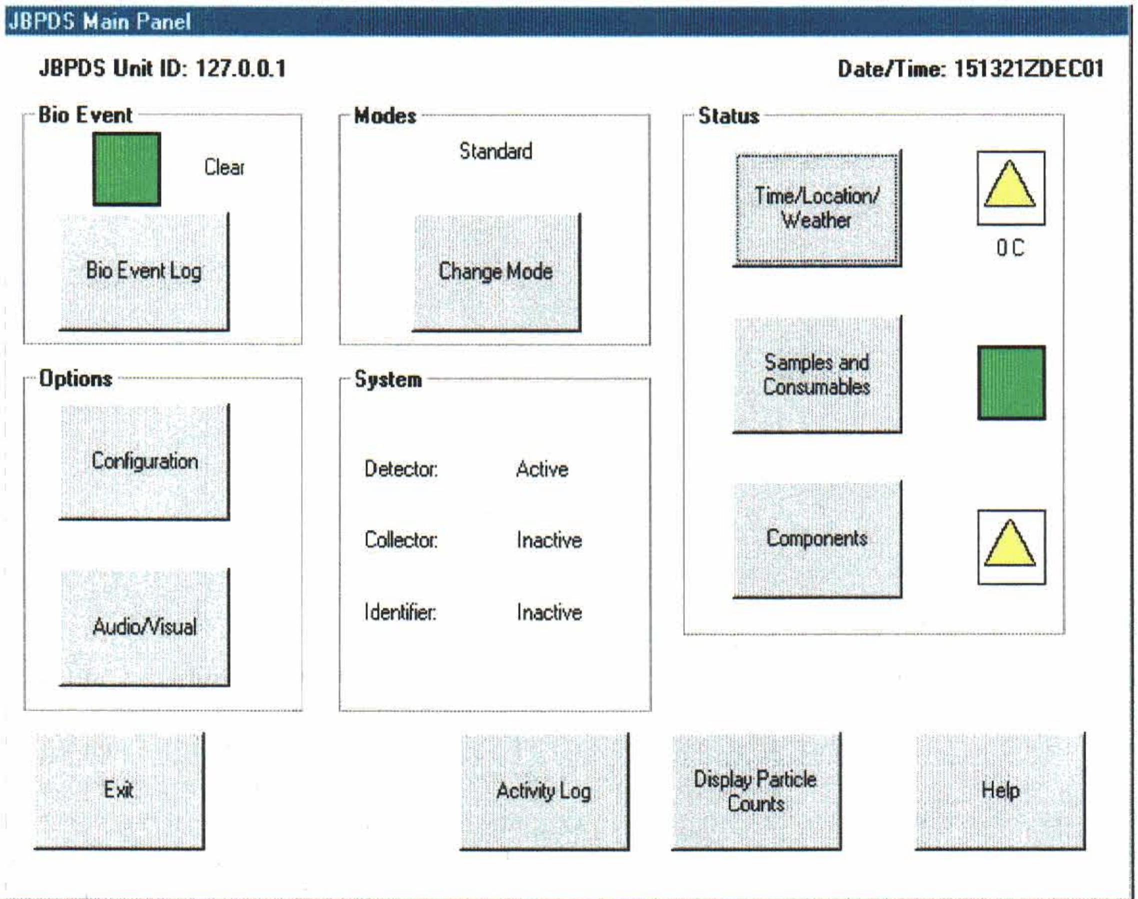

Figure 6. JBPDS Main Screen

This screen provides the overall information for system operation. The Bio Event Log provides a summary of all system detections and identification processes. This gives the operator an overall log of the bio detection and identification events. The Option Section provides the operator a means to modify the configuration of the JBPDS, such as set up for operation on a network with other JBPDS and a command center. It also provides a means to change both the audio and visual set up of the JBPDS, such as day or night time display and enabling or disabling of the audio alarms and alerts which occur. The Modes Section provides the means to change the system mode of operation (it displays current mode of operation, standard). The Status Section provides the operator with an overview of the system. Current position, time, and weather can be displayed, status of all the system consumables, and an overall status of the system components.

The Activity Log shows a summary of the system activity during operation, display particle counts gives the operator a general view of the activity from the BAWS. As the particles counts change and reach a set threshold within the BAWS, an alarm condition occurs. The System area shows the status of the detector (BAWS), collector, and identifier. The system is in standard mode and the detector is active (continuously monitoring the background air). The collector and identifier are inactive until a detection event occurs. When an event does occur, the detector will show alarm and the collector will be active for the collection period and the identifier active for the identification period.

The normal mode of operation for the JBPDS is standard. In this mode, the BAWS continually monitors the background air for any changes indicating the presence of biological material. When the BAWS detects the presence of a bio aerosol, it alarms and triggers the rest of the system. The operator is alerted by the system with a positive detection pop up screen as shown in Figure 7.

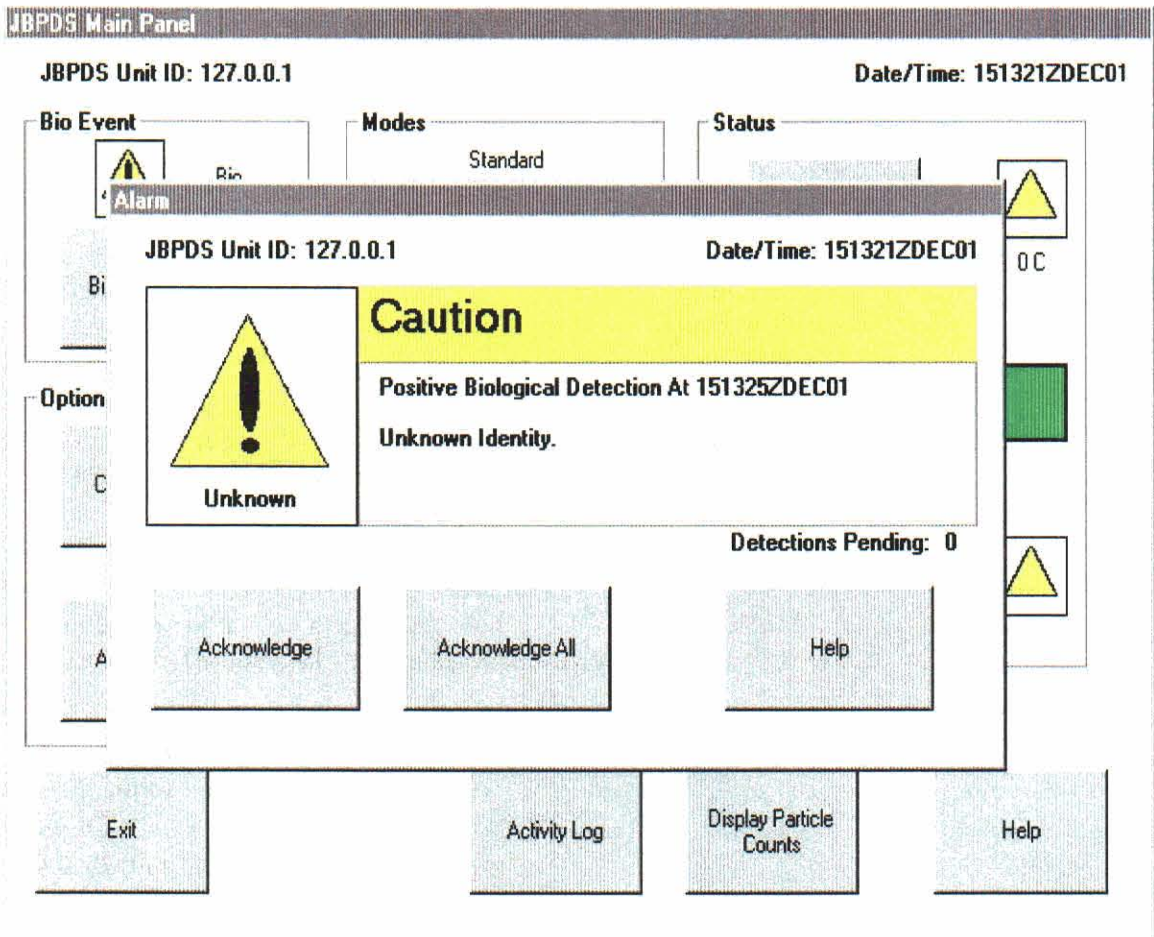

Figure 7. Positive Biological Detection

A positive detection by the BAWS automatically starts the collection and identification process. The operator must acknowledge this detection to clear it off the screen. The positive detection event will be entered into the bio event log. After approximately 20 minutes, the system will have completed the automated identification process and provide this information to the operator through another pop up screen. The screen will display either a positive or a negative identification. Figure 8 shows the pop up screen for a positive identification.

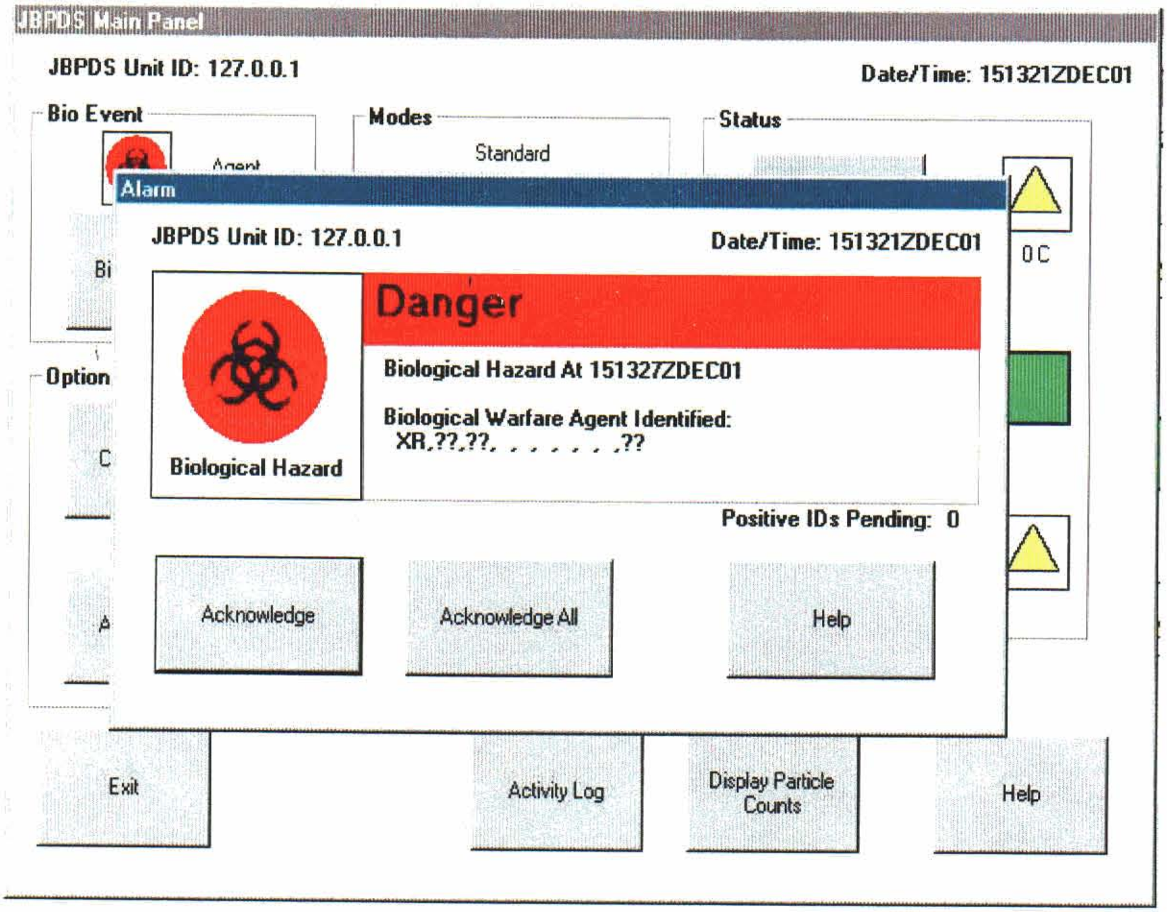

Figure 8. Positive Biological Identification

The system then moves the remaining 4 ml sample to the appropriate container (one of the separate vials for a positive and the common bottle for all negative identifications). The results of the identification event are also stored in the bio event log. Acknowledgement of this screen completes the identification process.

The JBPDS can also be operated in a periodic mode, which continuously collects and processes samples at a set frequency. The operator can program the system to periodically collect from 5-120 minutes in 5-minute increments. A single sample may also be taken at any time. Extreme cold weather operation occurs when the outside temperature reaches -8°C. At this point, the operator is alerted to put the system into extreme cold weather operation. In addition, the operator must install a dry filter on the collector inlet stack. At these low temperatures, it is difficult to move the fluids within the system and all identification must be done by hand. After a collection, the dry filter is removed and processed by hand. The filter is placed within a container of buffer solution, and then this liquid sample is hand inoculated into the assay strips and read by the human eye.

3.3.6 Radiological Detection

An attack carried out by a terrorist group may consist of a release of radiological material. Radiological material dispersed will emit alpha, beta, gamma, or neutron radiation. The properties of these four radiation types playa very important role in the determination of the relative hazard that they present. Alpha radiation consists of large positively charged helium ions that impart their energy in a localized area (i.e., cells or tissue). Alpha radiation has a very short range in air and does not have enough energy to penetrate through the dead layers of skin; therefore, no living tissue will be damaged for an external exposure. However, if alpha emitting particles are ingested or inhaled into the lungs, they can act directly on living tissues. F or this reason, alpha radiation is considered only an internal health hazard. Beta radiation consists of high-speed negatively charged electrons emitted from the nucleus; the electrons have a continuous energy spectrum and can penetrate farther than alpha particles but do not cause damage beyond the epidermal layer. However, if beta-emitting particles are inhaled or ingested, they can act directly on living tissue and become a health hazard. For this reason, beta-emitting particles are considered an external hazard to the skin as well as an internal health hazard. Gamma radiation consists of high-energy electromagnetic waves that have the ability to penetrate through skin and clothing. Therefore, gamma radiation is considered a significant health hazard since it poses a greater external hazard than alpha and beta radiation. Neutrons are high-energy neutral particles emitted from the nucleus. Neutrons have a long range in air and can move freely through matter. As neutrons travel throughout the body, their interactions tend to extend into the deeper radiosensitive body tissue. Neutrons are normally produced as a result of fission either in a nuclear reactor or from a nuclear detonation. Neutron radiation is more effective in producing body tissue damage than gamma radiation, thus posing a significant ex al hazard.

Potential sources of radiological material include Cobalt-60, Cesium-137, and Plutonium-238, 239. Cobalt-60 is a radiological material that emits both beta and gamma radiation and is used to sterilize surgical instruments, blood irradiators, and improve the safety and reliability of industrial fuel oil burners. It is also used in cancer treatment, food irradiation, and radiography. Cesium-137 is a radioactive material that emits beta and gamma radiation. It is used for medical treatment and for process control in industry. Plutonium-238, 239, and 240 are radioactive materials that emit both alpha and gamma radiation, artificially produced by the bombardment ofUranium-235. Plutonium-239 is used in nuclear weapons and Plutonium-238 is used as a heat source and to power spacecraft. High levels of internal exposure to these types of radiological materials may cause serious health effects or death.

The effectiveness of radiation, regarding any adverse health effects caused by exposure to radiological material, is highly dependent on many factors. The two types of radiation exposure that will be discussed here are prolonged internal exposure and prolonged external exposure. Prolonged internal exposure from radiological material may occur through inhalation, ingestion, and absorption (i.e., through cuts or wounds). The adverse health effects of prolonged internal radiation exposure is dependent upon factors such as quantity of material (i.e., internal uptake), cell radiosensitivity, radiotoxicity, biological half-life, and solubility in the body.

Radiosensitivity is defined as the susceptibility of cells, tissue, organs, or any living substance to absorb a non-biological substance that causes the poisoning of tissue or cells. Radio toxicity is defined as level of toxicity that the particular radiation will have. Another factor that may affect the health hazard is the rate at which a radioactive material is eliminated from body tissue, body organs, lungs, and bones. This is referred to as the biological half-life. For example, the less time it takes for a radiological material to reach its biological half-life, the quicker it is eliminated. Solubility determines the ability of a radiological material to absorb into the lungs, body tissue, and body organs. For example, if an insoluble radioactive material is inhaled or ingested into the body, it will tend to remain in the lungs and gastrointestinal tract long enough to cause significant damage.

Prolonged external exposure from sources such as food, blood irritators, x-rays, or spent reactor fuel may cause serious health effects. The adverse effects of prolonged external radiation exposure is dependent upon factors such as exposure time, distance, shielding, and exposure to vital organs such as blood forming organs. The exposure time is an important parameter in determining the level of external exposure to a radiological material because the less time spent within a radiation field, the lower the total dose received. The distance from the radiation source is another important parameter in determining the level of external radiation exposure because the dose decreases exponentially with increasing distance from the source. Shielding the radiation source can also reduce the amount of external radiation exposure. See Table 10.

Table 10. Radiation Shielding

Type of Radiation	Shielding Required	Remarks
Alpha	Clothing, paper, air	Range < 10 cm in air
Beta	Aluminum sheet, other light metals	Range < 30 cm in air
Gamma	Lead, tungsten, steel, concrete, or other high density media	Detectable at long range
Neutron	Hydrogenous material such as paraffin or water, <u>plus</u> high density media	Neutron radiation generates secondary gamma radiation when it interacts with hydrogenous material

Given the availability of nuclear reactors for research or energy production by local universities, research facilities, or private industries, the threat associated with radiological materials is significant. Radiological materials, in particular, Cobalt-60 and Cesium-137, may be obtained by a terrorist organization through hospitals, research laboratories, universities, and some ionizing smoke detectors. Uranium-235 and Plutonium-238, 239, and 240 are not as easily obtainable; however, they pose a significant health hazard due to their radio toxicity and psychological effects.

Alpha radiation has a range in air of less than 10 cm, and it is almost invariably accompanied by gamma radiation. This secondary gamma radiation will permit the use of a gamma detector for many of these sources. Beta particles are energetic electrons. They have a range of only about 30 cm or less in air. If the source of beta radiation is dispersed in air, it is very likely that an air filter and pump arrangement would be needed to concentrate the source to levels above the detection threshold. However, a pure beta source (e.g., Strontium-90) with an activity large enough to have significant health effects will also emit secondary gamma rays, or Bremsstralung radiation, from interaction with any surrounding material. These gamma rays will then interact with a gamma detector exactly as if they had been emitted directly from the source. Neutron radiation is almost invariably accompanied by direct gamma emissions, which can be detected using standard NaI gamma detectors. Gamma radiation travels long distances in air, and it can usually be detected several meters from a source.

3.3.6.1 Radiation Detectors

Detection of radiological materials within the building was conducted utilizing NaI gamma radiation point detectors. The Special Technologies Laboratory (STL) of Bechtel-Nevada manufactured the standard sodium iodide thallium doped (TI) crystal detector chosen to meet the requirements of the Smart Building Program (Figure 9). The Radiation Detection System came with the detector assembly, a local alarm indicator and a lead shield collimator (Figure 10). System specifications are shown in Table 11.

Table 11. STL Radiation Detector Specifications

Component	Size	Weight	Power	Interface
Detector assembly	10.25 inches long x 1.625 inch radius	3.81 lbs.	120 VAC, 50 mA max	LonWorks serial bus
Collimator	16.0 inches long x 2.5 inch radius	N/A	N/A	N/A
Detector with collimator	N/A	32 lbs.	N/A	N/A
Local Alarm Indicator	3.5 inches x 4.5 inches x 2.25 inches	1 lb.	N/A	N/A

Figure 9. Radiation Detector System

Figure 10. Collimated Container

The Local Alarm Indicator is generally used in the immediate area where the radiation detector is located. The Local Alarm Indicator provides a guard or other operator with an audio warning when gamma radiation above normal background is detected. An alarm level indicator is also provided. The range of alarm levels is from 1 to 9 with nine indicating a high level of gamma radiation has been detected. A zero indicates no alarm. The local alarm indicators were used in the west lobby and parking garage by security personnel.

The Lead Collimator would be used when the detector is installed in areas where shielding is necessary due to nearby x-ray machines. The Lead Collimator would also be used in applications where it is desirable to focus the radiation detection on a specific area. It was not used in the Smart Building application.

Figure 11. Radiation Detector Local Alarm Indicator

Figure 12. Exterior Site Radiation Detector Installation (at Top)

3.3.7 CBR Detection Inside the Building

The internal CBR detection equipment identified above was located within the following areas of the building (See Table 12):

- West Lobby – To provide warning of a chemical or radiological challenge initiated in the West Lobby.
- Building Outside Air Intake – To provide warning of an external chemical or radiological challenge that has entered into the building through the outside air intake grilles.
- Top of Building Return Airshaft – To provide warning of a chemical or radiological challenge initiated from inside the building on floors 1 through floors 4.
- Penthouse Mixing Room – To provide warning of a biological challenge that initiated either inside or outside the building, but has entered into the mixing room, where the return air and make-up air are mixed together prior to being filtered and supplied throughout the building.
- Fifth Floor Elevator Lobby – To provide warning of chemical challenge that originates from the elevator or floors 1 through 4, especially the elevator lobbies. Additionally, monitors the integrity of the protective envelope during decontamination procedures.

Detector locations were selected by using engineering judgement of how the air flowed throughout the building, particularly outside the protective envelope. This understanding was aided by the use of a computerized model developed for DTRA, known as the Planning Response – Evaluation of Airborne Chem/Bio Threats (PREACT™) model. PREACT™ was developed to predict the concentrations and dosages throughout the building resulting from a chemical release at any location. Tracer gas tests were used to confirm the PREACT™ predictions for the conditions upon which detector location decisions were made. (See Volume 4 for further discussion of the PREACT™ model.)

Table 12. Internal CBR Detector Locations

Location	RAID-1	CW Sentry Plus	JBPDS	Radiological Detection System
West Lobby	1	1	0	1
Outside Air Intake	2	1	0	1
Top of Building Return Air Shaft	1	1	0	1
Penthouse Mixing Chamber	0	0	1	0
fifth Floor Elevator Lobby	0	1	0	0
Parking Garage Entrance	0	0	0	1

Note: The main purpose of these detectors is to provide advanced warning of a threat and to allow the building to automatically respond and limit the spread of the contamination throughout floors 1 through 4.

Detector communications were tested to assure that a positive detection at any location would result in the correct automated building response.

Background testing began with the installation of the first fully functional detector stations on January 8, 2002, and continued through the final preparations for the special events.

3.3.8 CBR Detection Outside the Building

The external chemical detection equipment chosen to accommodate the requirements of the Smart Building Program was the CW Sentry Plus from Microsensors, Inc. The JBPDS was used as the external biological detector. The Bechtel-Nevada radiation detector was used for external radiological detection.

Each external CBR detection location was equipped for AC operation with an uninterruptible power supply (UPS) backup. The output signals from the chemical and radiological detectors were electronically transmitted to the Control Room. The JBPDS detector was monitored separately at a satellite control room located in an adjacent building. The Smart Building Control Room had direct communication to the JBPDS satellite control room using an Aiphone® intercom, telephones, and a direct computer link.

The external CBR detection equipment identified above was located as indicated in Figure 13 and listed in Table 13:

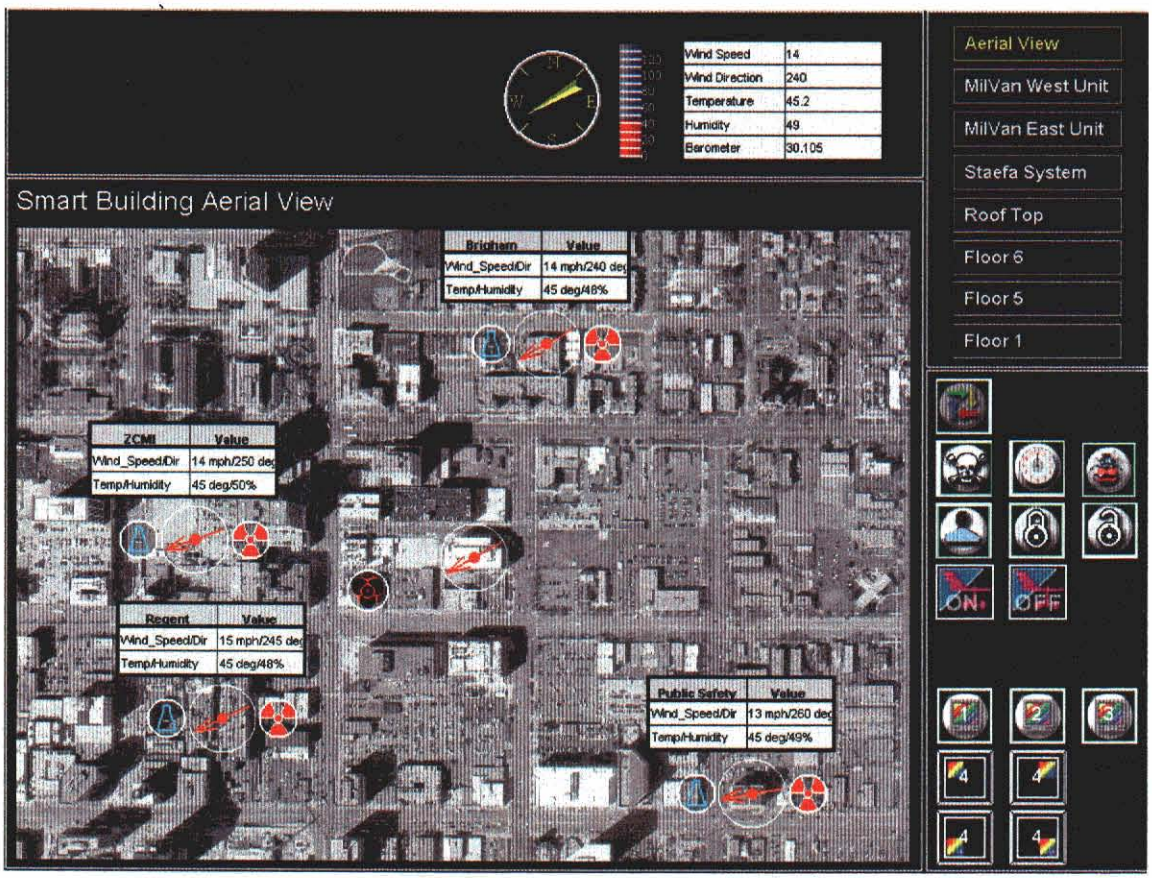

Figure 13. On-Screen Image; Aerial View of Social Hall Vicinity

Table 13. Exterior CBR Detector Locations

Building Name and Location	Functions	CW Sentry Plus	JBPDS	Radiation Detection System
SLC Public Safety Building, 305 East and 200 South	Provides warning of a chemical or radiological challenge approaching the building from the southeast direction.	1	0	1
Brigham Apartments, 201 East South Temple	Provides warning of a chemical or radiological challenge approaching the building from the northeast direction	1	0	1
Regent Street Parking Structure (S. Elevator), 161 South Regent Street	Provides warning of a chemical or radiological challenge approaching the building from the southwest direction.	1	0	1
ZCMI Center Parking Garage, 36 South State Street	Provides warning of a chemical or radiological challenge approaching the building from the west direction.	1	0	1
Key Bank Building, 79 South State Street	Provides warning of a biological challenge approaching the building from the southwest. One JBPDS was located on the roof.	0	1	0

Upon installation of the detection equipment, environmental background testing was conducted to assess the frequency of false alarm occurrences at the detector sites.

Background testing began with the installation of the first fully functional detector stations on January 8, 2002, and continued through the final preparations for the special events.

3.3.8.1 Toxic Industrial Material Subscription Service

The Toxic Industrial Material Subscription Service (TIMSS) was designed to integrate point detectors into an external detection system. Design provisions were made to allow for overlapping networks of multiple Central Information Servers (CIS), with each CIS having up to 32 Meteorological (Met) Towers (see Figure 14).

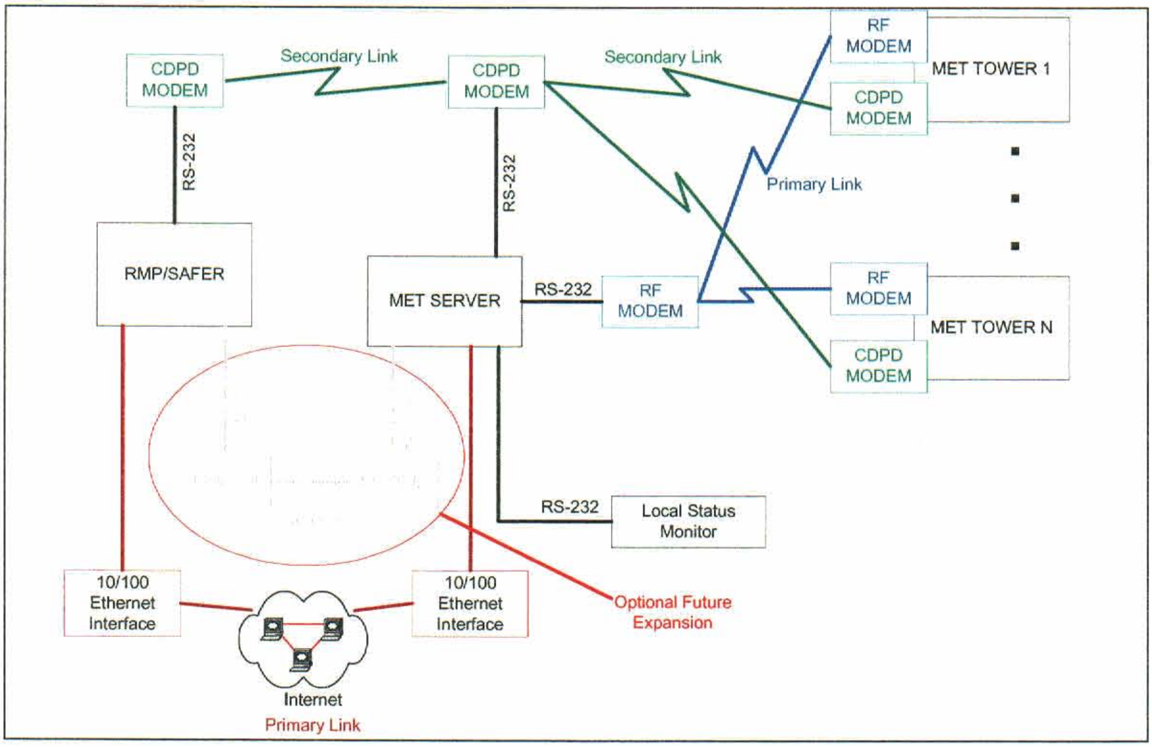

Figure 14. TIMSS Overview Diagram

The system was designed to transfer data from the Met Towers over a wireless interface to a CIS, where command frames and data request frames would be sent from the Server to the Tower, and command responses and data frames would be sent from the Tower to the Server. The intent was to utilize the RF modem for all data transfers with the cell modem available as a backup in case the RF communication link failed. All data packets were designed to be sent out over the same frequency.

The CIS provides the capability to collect meteorological, chemical, radiological, and biological data and report the data to a backup remote server. The CIS also reports the Met Tower status to a Local Status Monitor (LSM) that is connected to each Met Tower system.

The development of this system was not completed in time to support the Olympics. Prototype testing was completed following the Olympics and additional testing may be performed to better characterize this system as a follow on effort to the Smart Building Program.

3.3.9 CBR Detection System Lessons Learned

3.3.9.1 Building Airflow Modeling

The PREACT™ model was a useful tool for predicting building airflows, but it was based on preliminary building design information, and there was insufficient time to incorporate corrections to compensate for changes made to the building. Future building protection efforts would benefit from having an airflow model designed to readily incorporate empirical data from tracer gas experiments performed in the final building configuration.

3.3.9.2 Technical Support for Detectors

Technical issues associated with the Bruker Daltonics RAID-1 detectors could not be quickly resolved due to difficulties in communicating with the appropriate technical personnel that were located outside the United States. The dust filters were changed as required. However, another filter located inside the detector could not be changed in the field. The detector must be sent back to the manufacturer in order to change the filter. Battelle did not find out about this until after the detectors had been selected and purchased.

Selection of detectors should consider the availability of technical support from the manufacturer. Hence, a decision to use a detector from a foreign supplier should be even more closely evaluated.

3.3.9.3 Use of Hand Held Detectors

Resolution of a chemical alarm might have required that response personnel use the hand held detectors that were obtained. Personnel that would be using the detectors needed to be properly trained, equipped, and qualified in the use of personnel protective equipment and the handheld detectors. The integration of response personnel and equipment should be fully defined and integrated into the overall WMD response plan well in advance of the special event.

The radiological detectors did alarm at first, as expected, when their sensitivity levels were being adjusted. The detectors used are sensitive enough to register the presence of even the small amount of ionizing radiation emitted by people who have recently had medical tests or treatments involving radioisotopes. The handheld radiation detectors were used on several occasions when resolving such alarms. The detector sensitivity was adjusted to alarm only when such people entered the lobby, and not when they merely passed by on the sidewalk outside the building.

3.3.9.4 Investigation of Level 1 Biological Alarms

The process developed by the JBPDS program office and Battelle to confirm whether an automated identification was actually a true alarm worked very well and prevented over-reaction to Level 1 JBPDS alarms during the Olympics.

3.4 Electrical Distribution System

A new electrical distribution system was installed for the fifth floor, sixth floor, and CP system in order to allow all of these systems to be placed on backup emergency power. A 1000-kilowatt emergency generator was installed on the P-3 level of the parking garage. The automatic transfer switch was located in the electrical room on the P-1 level of the parking garage. Electrical power was routed through the transfer switch and up to three electrical distribution panels (EDP) and a transformer located in the penthouse. The electrical power conduits were run from the parking garage up the east stairwell and into the penthouse.

The electrical distribution system consisted of three EDPs located in the penthouse near the return airshaft: The EDPs shown in Figure 15 served the subsystems identified in the following tables.

Table 14. EDP 1 – 1200 Amp Main with 480/277 Volt, 3 Phases

Designation	Subsystems Supplied
Panel 5L	Fifth Floor Lighting Panel
Panel 6L	Sixth Floor Lighting Panel
EDP2	Supply to EDP2 through Transformer
EDP3	Supply to EDP3

Table 15. EDP 2 – 1000 Amp with 208/120 Volt, 3 Phases

Designation	Subsystems Supplied
Panel 5A	Fifth Floor Electrical Panel
Panel 5B	Fifth Floor Electrical Panel
Panel 5C	Fifth Floor Electrical Panel - Clean Power
Panel 6A	Sixth Floor Electrical Panel
Panel 6B	Sixth Floor Electrical Panel
Panel 6C	Sixth Floor Electrical Panel - Clean Power
P1	Condenser Water Pump
P2	Backup Condenser Water Pump

Table 16. EDP 3 – 800-Amp with 480/277 Volt, 3-Phase

Designation	Subsystems Supplied
FS-1	Filtration System 1
AF-1	Filtration System 2
HU-1	Boiler Unit
AHU-1	Air Handling Unit 1 - Trane System
AHU-2	Air Handling Unit 2 - Trane System
AHU-3	Air Handling Unit 3 - Trane System
AHU-4	Air Handling Unit 4 - Trane System
CRU-1	Computer Room A/C Unit 1 - fifth Floor Liebert
CRU-2	Computer Room A/C Unit 2 - sixth Floor Liebert
CRU-3	Computer Room A/C Unit 3- fifth Floor Radio Room Liebert
EP-1	Existing Water Supply Pump 1
EP-3	Existing Water Supply Pump 3
EB-1	Existing Boiler
EB-5	Existing Water Supply Pump 5
RF-1	Relief Fan in Penthouse
CT-1	Cooling Tower Fan
EL-1	Service Elevator

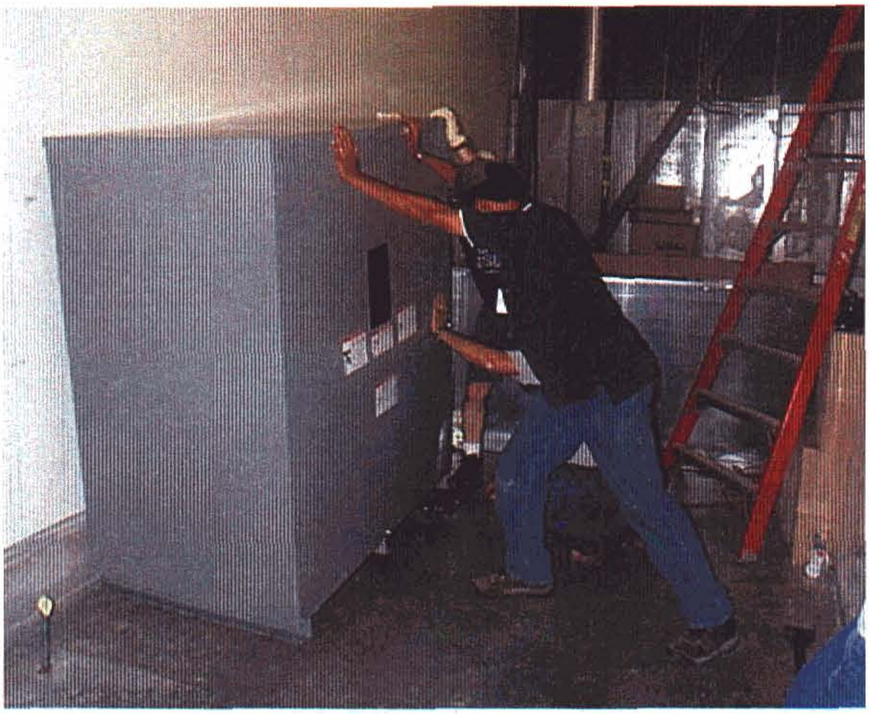

Figure 15. Installing Transformer for the Electrical Distribution Panel in Penthouse

When the new electrical system was fully installed, each EDP and circuit was tested for polarity, grounding, and capacity. The same tests were also performed under emergency generator power.

3.5 Emergency Power System (EPS)

A 1000-kilowatt emergency power generator was installed on the third level of the parking garage along the south wall. This generator would have supplied electrical power to the fifth floor, sixth floor, and CP system in the event of a power outage. The south wall of each level of the parking garage contained two large openings that were normally used to exhaust fumes from the parking garage. The area directly in front of the large opening on the east side of the building was selected as the location for the placement of the emergency power generator. This location allowed the exhaust from the generator to be piped up the side of the building and released above ground level, which prevented any hazards associated with the generator exhaust. In addition, this opening allowed the generator to be refueled from street level. The area around the generator and fuel tank was protected by concrete barriers and fencing inside the parking garage and fencing and louvers at the large opening from the parking garage used to ventilate exhaust fumes from cars.

The unit selected was a standby-rated, automatically started diesel engine coupled to an AC generator unit. The diesel engine was equipped with a jacket coolant heater and a crankcase heater to allow the generator to start automatically within 10 to 15 seconds. All critical systems were on UPS to allow normal operations to continue in the event of a power failure. A 2000 gallon concrete lined fuel tank stored diesel fuel oil grade DF2 sufficient for a minimum of 24 hours of continuous operation.

The batteries used for starting the diesel engine were equipped with sensors that would report abnormal battery or battery charger voltage to the generator control system and remote monitoring panel located in the sixth floor control room (Figure 16).

Figure 16. Remote Instrument Panel for Emergency Generator

The diesel engine and AC generator set was tested individually and as a complete system at the factory. Testing confirmed sustained functioning under partial, full, and overload conditions. The generator was tested using a portable load bank and under full building load after the CP system was operational. These tests confirmed that the Operator's Manual is correct and applicable, that the generator instruments and controls are fully functional, and that the remote panel displays the same readings as the local panel.

The emergency generator was programmed to automatically start the engine and run it for 30 minutes, once per week. These tests were completed without any significant problems.

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3.5.1 EPS Lessons Learned

The emergency generator was extremely loud, and hearing protection was required for any personnel in the vicinity whenever it started. This could be a potential problem in future applications. It could be overcome by designing a sound-suppressing enclosure for the EPS.

Delineation of the work being performed by the contractor working on the building modifications and the electrical contractor selected to purchase and install the emergency generator either needs to be combined under the building modifications contractor from the very beginning of the program or better delineated in the design drawings.

3.6 Physical Security

3.6.1 External Barricades

Physical security barriers were installed on Social Hall Avenue and 200 East in order to limit the access a potential terrorist may have close to the building. The barriers were installed in the traffic lane closest to the building, and Social Hall Avenue was turned into a one-way street with the traffic flow altered to allow vehicles to proceed from west to east. Barricades were also installed on 200 East to prevent vehicles from parking near the building on the west side of 200 East. These barriers extended past the south side of the building and blocked the opening near the gas main on the southeast corner.

Figure 17. Social Hall, Showing East Lobby Entrance and Barriers

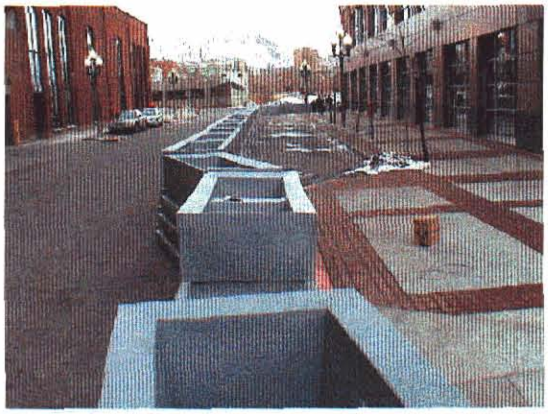

Figure 18. Social Hall Avenue, Showing Barriers Along North Side of Smart Building

3.6.2 Entering the Building

Everyone who entered Social Hall Plaza on foot from January 21, 2002 through February 26, 2002 was required to enter through the west lobby. Upon entering the west lobby, personnel that did not have a badge issued by one of the building tenants were required to pass through a security checkpoint. Personnel who did not have an approved badge were required to pass through a magnetometer, and all parcels were X-rayed.

After passing through the checkpoint, personnel were able to proceed to the main building elevators or the first floor hallways.

Personnel that entered the stairwells on floors 1 through 4 were prevented access to the fifth and sixth floors by physical barriers that were emplaced in the stairwells. Each barrier contained a door with a Hirsch pad to enable authorized personnel to access the fifth and sixth floors. Additionally, these doors were equipped with crash bars to allow for emergency egress.

Access to the Social Hall Plaza parking garage was limited to personnel that work within Social Hall Plaza. Vehicles entering the parking garage were required to pass a security guard who monitored all vehicles as they entered and exited the garage. Personnel entering the building from the parking garage (stairwell or elevators) were directed to the west lobby security checkpoint. Each stairwell contained a physical barrier to prevent personnel from continuing up the stairwell to the second floor and bypassing the west lobby security checkpoint.

Since the east lobby and stairwell were made inaccessible from outside the building during the special event, the Internal Revenue Service (IRS) established a small self-service area in the west lobby where taxpayers could obtain Federal Income Tax forms. This area was located outside the security perimeter to allow personnel to obtain required forms without passing through the security checkpoint.

Deliveries to the building requiring use of the loading dock were limited to scheduled deliveries. Drivers were met by SLC Police before being permitted to pull up to the loading dock at Social Hall Plaza.

3.6.3 Exiting the Building

Personnel with appropriate badges and identification cards descending through the east stairwell or walking from the first floor lobby were allowed to depart through the east lobby exit door without passing through the west lobby security checkpoint. All other personnel, including building employees that descended on the elevators were required to pass by the west lobby security personnel prior to leaving the building.

3.6.4 Entering the Fifth Floor

Personnel entering the fifth floor required an access badge in order to enter the mantrap from the elevator lobby. Personnel without a badge could ring a "call" button for a receptionist to check credentials and allow them to enter the fifth floor mantrap.

Personnel allowed to enter into the fifth floor could still be restricted from entering the Olympic Coordination Center (OCC). Only individuals who were assigned a badge allowing access to the OCC could enter this area.

A procedure was implemented to prevent any two doors from being open at the same time. This helped maintain the overpressure in the protective envelope and added to the physical security of the fifth floor operations. Additionally, the door on the south side of the elevator lobby into the protective envelope was secured, and access into the protective envelope through that door was restricted during the Olympics.

3.6.5 Entering the Sixth Floor

Personnel entering the sixth floor required an access badge to enter the mantrap from the elevator lobby. Personnel without a badge were held in the mantrap until the receptionist verified their credentials and the POC for their appointment or meeting. The POC was required to come to the mantrap and escort the individuals in cases where an "Escort Required" badge was issued.

Personnel allowed to enter into the sixth floor could still be restricted from entering the FBI Command Post. Only individuals with a security clearance at the level of "SECRET" and who had a specific need to be in that area were allowed to enter.

A procedure was implemented to prevent any two doors from being open at the same time. This helped maintain the overpressure in the protective envelope and added to the physical security of the sixth floor operations. Additionally, the door on the south side of the elevator lobby into the protective envelope was secured and access into the protective envelope through that door was restricted during the Olympics.

3.6.6 Physical Security Lessons Learned

Physical security provisions to prevent vehicles from approaching the building too closely should be considered as early in the site selection and planning process as possible. Architectural, zoning, and practical considerations may preclude a fully satisfactory solution for some sites. The water-filled barriers used in this program were an adequate temporary solution, but they were conspicuous and unattractive.

The building selected for the Utah Olympic Public Safety Command (UOPSC) Joint Operations Center was not a Federal Building and was not owned by either the Defense Threat Reduction Agency (DTRA) or the Federal Bureau of Investigations (FBI). Therefore, access into and out of the building could not be completely controlled. Also, due to the number of personnel involved from the various Government Agencies and private contractors, the transfer of clearances and issuance of badges resulted in some instances where a group of personnel arrived on scene to work on the project and were slowed down by not having the proper badges. This was particularly true at the start of the Olympics when additional personnel came in to run the operations centers and the personnel providing the badges were overwhelmed. In the future, contract personnel working in the building should be badged and approved prior to the large number of additional government support personnel arriving on-site.

3.7 Decontamination Operations

The flow of personnel into and out of the protective envelope following a confirmed CBR challenge on the building was considered and addressed as part of the Smart Building Program. Decontamination rooms were built into the fifth and sixth floors of Social Hall Plaza and a Decontamination Plan was developed to describe exactly what procedures should be followed during the processing of personnel into and out of the protective envelope. The Decontamination Plan is contained in Volume 4.

3.7.1 Decontamination Planning Lessons Learned

Battelle worked closely with DTRA to lay out the decontamination strategy and plan. It was rather late in the program when a qualified expert was brought under contract. The development of the Decontamination Plan should be the responsibility of the contractor that designs the decontamination rooms and the Government Agency sponsoring the program. Identification of exactly who will operate the decontamination rooms should be decided by the Government Agency that sponsors the program.

3.8 Control System

The control system was designed to bring all of the sensors to a termination point in the sixth floor control room located in room 663. The Data Integrator for Ground Sensors/Process Equipment Control System (DIGS/PECOS) control system was designed to receive and process sensor signals and implement the automated building response.

3.8.1 Data Integrator for Ground Sensors (DIGS)

The Data Integrator for Ground Sensors (DIGS) was used to process multi-sensor events and provide the processed information to the control system operator. The information status was presented on touch sensitive monitors in the control room for rapid assessment of alarms and potential responses.

The DIGS node consisted of a number of event driven processes. The first was the sensor detection association. This process determined whether sensor detections corresponded to the same event. Associated alarm data was characterized first by determination of the nature of the alarm (e.g. identifying a release and possibly an agent type). Following the alarm identification, the events were annunciated and responses actuated. Annunciations included both audible and visible notification of the control room operators.

The majority of the sensors for the Smart Building Program were connected to the control system through a local area network (LAN) using LonWorks as the communications protocol. LonWorks networks employ "distributed processing", whereby each device in the network can receive, transmit, and process network information independently of the other devices. This means that devices in the LonWorks network can make decisions and process information without the need for a dedicated computer, programmable logic controller (PLC), or some other form of central host processor.

3.8.2 Process Equipment Control System

The Process Equipment Control System (PECOS) is a distributed, robust, scalable architecture for facility monitoring and control. Modular Integrated Technologies (MIT) owns the Intellectual Property Rights to the PECOS system software. MIT assisted in the development of the control system. In addition to distributed functionality, the PECOS system nodes can be replicated to prevent specific functions from having a single point of failure. The distributive nature of the PECOS system has additional benefits in scalability since the overall network may be dynamically partitioned and viewed in whole or in part from multiple user displays. Thus, the PECOS system is robust and scalable.

Vendor Alarm Nodes are customized nodes for various sensors and building control functions. These nodes relay sensor status to the PECOS master node, where a determination is made with regard to which additional node or nodes need the information. PECOS provides a commercial off-the-shelf (COTS) interface for integrating with closed circuit television (CCTV) systems and alarm systems. The following vendor alarm nodes were incorporated into the control system for the Smart Building Program:

- CBR Sensor Interface – Allowed the sensor data stream to feed directly into the PECOS/DIGS control system during testing, status checks, and actual CBR challenges.
- Filtration System Sensors Interface – Allowed differential pressure and airflow sensors to process data directly into the PECOS/DIGS control system, which was monitored by control room operators located in the sixth floor control room.
- Automated Building Response Interface – Allowed the control system to receive chemical and radiological detection signals and then automatically adjust the Staefa Building Management System to an optimal configuration that would limit the spread of contaminants throughout the building. It also provided a communications link with the Staefa Building Management System to allow commands to be sent and received by the control system.

The PECOS master node acted as a "traffic cop" for the various subsystems and helped determine which alarm systems feed to which DIGS assessment nodes and displays. For low level (single sensor) alarms, the master automatically switched video feeds for the user based on alarm activations. The PECOS master node managed user permissions for the displays and determined the overall system connectivity.

The net logger node recorded all network alarm traffic for analysis and audit.

The two PECOS Display nodes served as the man-machine interface. They depicted various sensors and items to be controlled overlaid on building floor plans and pictorial diagrams. The control room operator used the display to obtain a status from the various alarms and other devices being monitored. The display mapped detections by causing an icon to blink and sounding an audible alarm. The operator could dispose of the alarm by use of buttons for "mark this as a real alarm", "mark this as a scheduled test or maintenance", or "mark this as a false alarm". The operator could also change a sensor's mode of operation if necessary, such as in case of a temporary false alarm problem. By touching various buttons, the sensor could be completely ignored, ignored unless it is being tampered with, or placed back into normal operation. On some screens, such as those controlling HVAC functions, the display could graphically represent the status of a particular HVAC component and could pass commands to components from touch-sensitive buttons and icons. The closed circuit television frame grab (CCFG) node integrated with a video switch to enable video feeds to video monitors. The CCFG allowed the system to automatically switch video cameras, either randomly or on alarm, to a camera covering the alarming sensor. In addition, the CCFG node was able to save a series of video frames associated with an event and replay those frames on the video monitors upon request or automatically as desired by the user.

UPS units were installed on the critical automated systems that would be degraded in the event of a power outage. These systems include the Control Room computer rack, Staefa Building Management Systems, LonWorks interface boxes, and various internal chemical and radiological sensor interfaces. The UPS would maintain those systems until the emergency power generator was fully activated.

3.8.3 Control System Design for Filtration System

The protective envelope of the Smart Building was supplied with filtered air from a CP System located on the roof of the building. The CP System consisted of two MCPFS units and a Boiler System. Each MCPFS had 11 pressure sensors that interfaced to the control system. The interface was made via LonWorks modules located within the MCPFS near the rear access doors. A LonWorks enclosure is shown in Figure 19. A LonWorks interface card was installed within the variable frequency drive (VFD) near the front access doors.

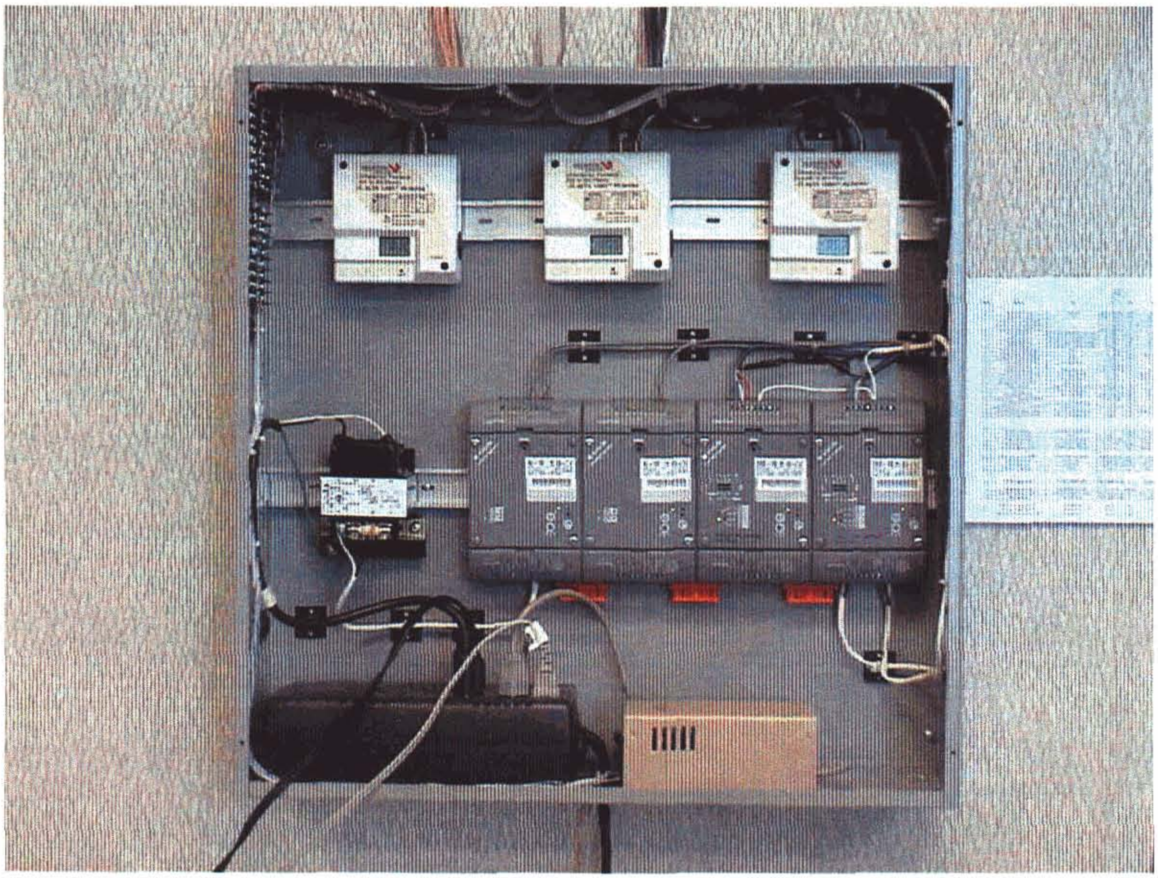

Figure 19. LonWorks Enclosure

The AI-10 LonWorks interface modules located near the rear access doors allowed the control system to monitor the differential pressure measurements across each bank of filters. Each AI-10 was an analog-to-digital converter that interfaced with two differential pressure transducers mounted on the FFA 1000-200 filter housings. There were 10 of these pressure transducers that measured the pressure differential across the

M56A1 filters. The differential pressure transducers were Veris Industries PX-100 (10 iwg range), 4-20 mA output, unidirectional devices.

An additional AI-10 LonWorks node and two PX-100 differential pressure transducers were located on the south wall of the Penthouse (near the Return Air dampers). These pressure transducers measured the pressure differential across the pre-filters and were of the same type as those located in the MCPFS.

The interface with the VFD allowed the control system to monitor and control the operation of the fan within each MCPFS. This interface was very complex and allowed the control system to modify approximately 200 parameters.

The control system utilized several screens to control the individual system components. Figure 20 and Figure 21 show the control screens for the MCPFS East and West units. Operators accessed the previously described interfaces through these screens.

Figure 20. MCPFS East Control Screen

Figure 21. MCPFS West Control Screen

In the graphical display of the MCPFS, the differential pressure transducers were shown in their approximate physical location by the icon shown in Figure 22. By touching the icon, the reading of the pressure transducer was displayed at the top left of the control screen. Similarly, the icon shown in Figure 23 graphically represented the operational state of the fan. By touching the icon, the state of the fan (either OFF or ON) was displayed at the top left of the control screen.

Figure 22. Differential Pressure Transducer Icon

Figure 23. Fan Operation Icon

The control system would provide a visual alarm on the control screen when:

- A differential pressure greater than 5.0 iwg or less than 3.5 iwg was measured across any of the M56A1 filter banks
- A differential pressure greater than 0.75 iwg was measured across the pre-filters
- MCPFS airflow was less than 75% of the set point of parameter 211 of the VFD.

3.8.4 Control System Design for Building Management System

Modern building designs incorporate building management systems to regulate the operation of the building's heating, ventilation, and air-conditioning (HVAC) system. The Social Hall Plaza building used a Staefa Building Management System. This system automatically regulated and balanced all of the components of the building HVAC system in order minimize the energy consumption required to maintain the building within acceptable temperature and humidity ranges.

A Staefa terminal was installed in the sixth floor control room. This terminal displayed the status of the various components of the building HVAC system and allowed control room operators to monitor the status of critical building components.

When an alarm was received from either a chemical or radiological detector the automated building response would be implemented from the control system through a direct interface into the Staefa Building Management System. The control room operators would use the Staefa Building Management System terminal located in the sixth floor control room to confirm that the correct response had been implemented.

3.8.5 Control System Design for Closed Circuit Television

A CCTV recording system was integrated into the control system in order to record video of specific areas following a CBR alarm. The CCTV cameras covered each of the areas inside the building where CBR detectors were located. Seven out of fifteen CCTV camera signals could be viewed simultaneously on the four monitors in the control room. By selecting the corresponding icon on the control system display screen, any signal could be displayed on any monitor.

The control system would automatically activate a recording of the CCTV signals from selected cameras whenever a CBR sensor alarmed. If sensors alarmed, the signals from the cameras in each alarm area would be recorded, up to the maximum capacity of the CCTV recording system. At that point, the control room operator would be given the option to choose which camera signals should be recorded.

3.8.6 Control System Design for CBR Detection

The internal chemical and radiological detectors fed into the PECOS/DIGS control system through the LonWorks network installed in the building. Sensor data was transmitted to the control system using the IEEE 709.1 network protocol (LonWorks). When an alarm was received from one of the chemical or radiological detectors, the control system would automatically adjust the building HVAC system and a visible (blinking) and audible alarm would occur in the sixth floor control room. The control room operators would review all available data, including CCTV, and follow the pre-approved alarm resolution procedure to determine if the alarm were an actual alarm or a false alarm. Once a determination was made, the proper steps to resolve the alarm would be implemented. Engineering judgment based on a detailed understanding of how the air flows throughout the building and nodal model simulations were used to develop the best automated building responses for actual CBR alarms. Two alternative responses, called "building flush" (BF) and "shelter" (SH), were selected.

The data output from the external chemical and radiological detectors was transmitted through a wireless radio frequency (RF) LonWorks channel into the control system where the detectors were monitored. All chemical and radiological detector alarms received by the control system would initiate the pre-selected automated building response.

A meteorological (MET) station was placed on the roof of the penthouse at Social Hall Plaza, and fed relevant MET data directly into the control system using the RS-232 communications protocol. One additional MET station was located at each of the four external detection system locations in order to provide current MET data (i.e., wind speed, wind direction, air temperature, barometric pressure, humidity, rainfall rate and accumulation). The MET data was collected in order to help the sixth floor control room operators determine how an actual or potential external alarm would impact Social Hall Plaza.

The JBPDS alarms were not delivered directly to the control system server. The JBPDS alarms were delivered directly to the satellite control room operated by fully trained JBPDS operators and subsequently to the sixth floor control room. Direct communications between the two control rooms allowed sixth floor control room operators to continuously monitor the status of both JBPDS systems.

3.8.7 Supplementary Fifth and Sixth Floor HVAC System

The ventilation and air conditioning system for the fifth and sixth floors of Social Hall Plaza was completely independent of the building HVAC system. The filtered air from the filtration system pressurized the fifth and sixth floors. The filtered air was heated to approximately 55°F, as required, using a natural gas fired boiler system located on the filtration system support platform on the roof. The filtered air entered the mechanical rooms on the fifth and sixth floors, where it was mixed with return air from each floor. The return air and filtered air was then conditioned using two 35-ton Trane AHU per floor. The existing supply air ducting on both the fifth and sixth floors was utilized for distributing the conditioned air evenly throughout the fifth and sixth floors.

The following differential pressure sensors were utilized to monitor the pressurization of the fifth and sixth floors:

- 4^{th} Floor to Fifth Floor Differential Pressure
- Fifth Floor to Sixth Floor Differential Pressure
- Sixth Floor to Atmospheric Pressure Differential

- Mantrap, Airlock, and Decontamination Rooms Differential Pressure

3.8.8 Remote Fire Alarm Annunciation Panel

The main building fire alarm panel was located on the first floor of the Social Hall Plaza building and presented certain vulnerabilities to the CP system. Whenever a fire alarm is activated in a building, fire codes require that the HVAC system be automatically shut down. If this rule were applied to the MCPFS, it would defeat the protective envelope. Therefore, an arrangement was made with the SLC Fire Department for a remote fire alarm annunciation panel to be installed in the sixth floor control room, which allowed the fifth and sixth floors to be separated from the code requirements of the main fire alarm panel with regard to the automatic shutdown of the Trane AHU and the filtration system if a fire alarm was received.

Software modifications were implemented to ensure the building HVAC system was shut down during a fire alarm on floors one through four. However, this alarm would not shut down the fifth and sixth floor CP system. The CP system would only be shut down for a lower-floor fire alarm when the SLC Fire Department specifically directed that all air-handling devices be shut down.

If a fire alarm were received from the fifth or sixth floor, both the building HVAC system and the CP system would be shut down. This included the roof top filtration system and the Trane AHU on the fifth and sixth floors, as required by the fire code. The remote annunciation panel allowed the control room operators to monitor the building fire alarm status from the sixth floor control room. Additionally, control room operators would initiate contact with the SLC Fire Department as soon as the fire department arrived at the building and establish a method of communication and a direct point-of-contact.

3.8.9 Alarm Notifications

The sixth floor control room also included a system for paging key personnel following specified CBR alarms. The levels of alert were based on the specific alarm received and the circumstances existing at that time.

The notification requirements were prescribed for alarms received in the control room. The Control Room Operators were also able to access the E-Team network from within the sixth floor control room.

3.8.10 Control System Testing

Each subsystem was evaluated through extensive testing of subcomponents to insure they were working properly before the subsystem was brought on line and integrated into the overall control system. Once the individual subsystem controls were complete, compatibility and interface testing ensued. Testing and refinement of the control system continued throughout the entire time the control room was fully operational.

3.8.11 Control System Lessons Learned

3.8.11.1 Notification of Node Shutdown

On several occasions one or more of the control system nodes shut down without the control room operator knowing the nodes had closed. A software patch was developed to ensure the control room operators would be notified when a node "crashes". Extensive troubleshooting time prior to a major event is required in order to work out all of the "Bugs" associated with a first generation control system.

3.8.11.2 Building Response Time

There was a significant and variable delay time built in to the HVAC control system. Integrating the control system directly into the critical components of the ventilation system, instead of the building management system, could have significantly improved the building response times.

3.8.11.3 Control System Interface Design for Detectors

The late receipt of the chemical detectors resulted in problems associated with developing and testing the control system interface between the detectors and the control system. Future programs should recognize the very long lead time required to obtain chemical detectors and develop the control system interfaces.

3.8.11.4 Meteorological Data Management

Meteorological data was collected at selected locations around the building site and transmitted to the Control System to help predict the effects of wind and other conditions on external challenges and the protection systems. The instruments and the data links were less reliable than expected. Future efforts should focus on selecting and perfecting meteorological data systems beforehand.

3.8.11.5 Multiple Sensor Points for Differential Pressures

The differential pressures between the envelope and outside and between floors are important measurements in evaluating effectiveness of the collective protection system. The following gauges were used to read differential pressures: outside ambient to sixth floor, fifth to sixth floors, 4th to fifth floors, and building pressure differential which reads outside ambient to 2nd floor. The gauges for the first three were Alta Labs PX-010's which are bi-directional and read to three decimal places. The building monitor is the original gauge that is unidirectional with less precision.

The three envelope-monitoring gauges read from single tubes that are split for multiple gauges. This helps to minimize error caused by local variations within a floor when calculating pressure not read directly by a gauge by reading to the same point. Also, the measurement tubes are located centrally within each floor in hallways to help minimize local effects. The outside ambient air tube is particularly susceptible to variations caused by wind. The variations in wind gusts can cause the pressure gauge to fluctuate on windy days. Placing a special tip on the end of the tube that restricts the opening and helps block the wind reduced this fluctuation. A steady wind, especially from the south, builds up pressure against the side of the building and causes the apparent envelope pressure to be low, while if it were read from the leeward side of the building it would be slightly higher than actual. These variations are not important in typical HVAC building controls. However, they can be critical in measuring the effectiveness of the CP system.

In the future, it is recommended that multiple sets of gauges be used for each reading. Outside measurement points should contain a special tip to limit the effects of the wind. Additionally, if possible, sensors should be placed on all sides of the building to further mitigate the effects of the wind. Differential pressure readings between the protective envelope and ambient pressure should be recorded relative to each floor when possible. Multiple gauges will provide better averaging as well as redundancy in case of gauge failure.

4.0 Normal Operations

4.1 Filtration System Operations

The Smart Building CP system could operate either as a fully stand-alone system or as an integrated component of the control system. Manual adjustments could be made either at the VFD inside the MCPFS or at the display panels on the control system monitors. An electrical disconnect switch was mounted on the outside of the Final-Filter component of the MCPFS. With power supplied, the disconnect switch in the ON position, all circuit breakers internal to the MCPFS ON, and the internal VFD in AUTO Mode, the CP system would begin providing filtered air through the external ductwork and into the protective envelope.

The amount of filtered air supplied by the MCPFS was controlled through the VFD located within the Final-Filter component of the system. A LonWorks interface card in the VFD also allowed control of the MCPFS through the control system. The volume of air delivered by the MCPFS was controlled via parameter 211 of the VFD. This parameter controlled the speed at which the MCPFS fan was run. It represents the percentage of full-scale frequency (i.e. 50% corresponds to 30 Hz and 100% corresponds to 60 Hz).

4.2 HVAC System Operations

During normal day-to-day operation, the building HVAC system was not disturbed by the control room operators. If configuration, pressure, temperature or other anomalies were reported by control room sensors, they were recorded in the control room logbook and then reported to building management personnel.

4.3 CBR Detection System Operations

If an initial chemical or radiological alarm was received and believed to be an actual alarm, a Level 1 Alert page would be sent from the control system to a selected list of individuals representing DTRA, FBI, Battelle, SAIC, Bechtel-Nevada, and ENSCO.

The military Liaison Officer would notify the Director of UOPSC and the DTRA Military Decontamination Team. If a second chemical or radiological alarm was received and verified as an actual challenge on the building, a Level 2 Alert would be initiated and a second page would be sent.

Note that although the Special Agent in Charge for the FBI and the Director of the UOPSC were not specifically identified on the list of personnel to be notified by the automatic pagers, on-site personnel coordinated with these personnel directly.

4.4 Electrical Distribution Operations

The electrical distribution system normally operated without intervention. If a line power interruption were to occur, the emergency generator would start automatically within 15 seconds. When line power was restored, the emergency generator would shut down, and line power automatically supplied the distribution panels located in the penthouse. The UPS would prevent the loss of computer controls and sensor signal transmissions on critical circuits during the short interval between the loss of "line" power and the start of the emergency generator.

In the event of any electrical power interruption, such as a circuit breaker actuation, appropriate actions would be taken by the control room operators to correct the situation. If the situation could not be promptly corrected the building owners and/or designated electrical sub-contractor would be notified.

4.5 Emergency Power Operations

The adjustment, operation, and maintenance of the emergency generator system were demonstrated to the building management personnel, and the installation contractor provided adequate training. The emergency generator was pre-programmed to start automatically every Tuesday evening and run for 30 minutes as a confirmatory system test and to eliminate any moisture condensation in the engine.

4.6 Control Room

4.6.1 Control Room Layout

The control room was located on the sixth floor in room 663. Figure 24 and Figure 25 show the layout of the control room. The CCTV monitors are shown mounted on the wall above the desks. Not visible are the control panels for the remote emergency generator panel, the remote fire alarm panel, server rack, a Staefa terminal and monitor, and a computer for receiving feedback and status from the JBPDS. The JBPDS status computer was not connected directly into the main server for the control system because the JBPDS operators manned the JBPDS satellite control room in the Key Bank Building on a 24/7 basis and logged all output data. The sixth floor control room also had fax and telephone message recording capability.

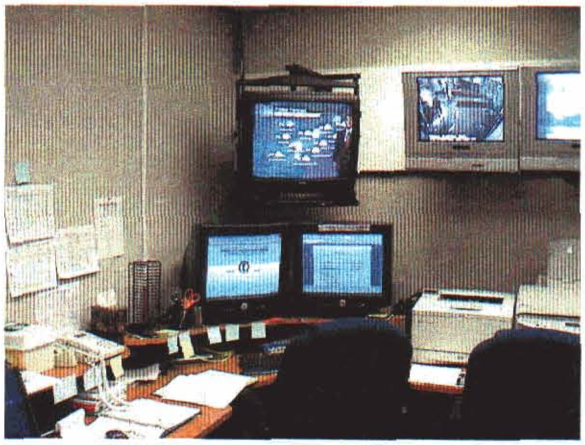

Figure 24. Control Room, Showing Battelle PC Dual-Monitors and Broadcast/Cable TV Above

Figure 25. Control Room, Showing CCTV Monitors Above, PECOS/DIGS Screens on Right

4.6.2 Control Room Staffing

The general mode of operation was to man the control room with two operators at all times during the special events. A staffing roster was developed that outlined personnel coverage and shift times.

The JBPDS Program Office maintained a full-time, 24/7, control center in the Key Bank building for JBPDS operations. Staffing of the JBPDS control center was the responsibility of the Program Office.

4.6.3 Data Collection and Retention

The control system was designed to automatically save and archive all sensor data inputs, commands and outputs.

The control system was designed to automatically save all CCTV signals in a digital data buffer. The control room operators could back up the buffer to CD storage media as necessary. The CDs would then be labeled and stored in the control room.

A logbook was maintained in the control room. Every significant event, action and incident was recorded in the logbook by the senior operator on duty.

The JBPDS satellite control room located in the Key Bank building maintained checklists and logbooks as the Program Office deemed necessary.

4.6.4 Operations Lessons Learned

4.6.4.1 Communication Links Between Control Rooms

Battelle installed a hard-wired direct telephone line between the sixth floor control room and the JBPDS control room on the 8th floor of the Key Bank Building. This direct line allowed the control room operators to quickly resolve any uncertainty resulting from temporary loss of JBPDS data communication. The JBPDS operators were able to reset the communications and quickly restore the system to full operational condition.

4.6.4.2 Management of CCTV Signals

The signals from 16 selected CCTV cameras could be displayed continuously, and a digital storage system permitted them to be reviewed without losing any recording. The next system should be expanded to allow all camera feeds to be sent into the control room.

4.6.4.3 Planning for the Unexpected

Many unforeseeable situations arose, for which no detailed planning could reasonably be done. Detailed Operations Plans and Test Plans were developed and refined continuously to guide the design and management of the Smart Building, but it is important that detailed plans not interfere with the optimum response to unforeseen events. The best preparation for that is to assure that qualified experts in every aspect of the operation; hardware, software, administration, etc., are immediately available.

4.6.4.4 Rooftop Antennas

Large directional antennas were placed on the roof very close to the MCPFS, by national security personnel, just prior to the Olympics. Some were obviously transmitter antennas, but the safety associated with the placement of these antennas was not revealed to Battelle. Battelle attempted to identify potential danger zones on the roof, but many contractor personnel regularly walked in front of the antennas.

Bechtel Nevada had to install higher power transmitters and receivers for the RF communication links to the exterior detector sites and move their antennas because of the electromagnetic interference caused by antennas installed on the roof just days before the Olympics.

Guidelines should be developed that regulate the placement of rooftop antennas to maintain access for maintenance and service and clearly identify hazardous areas. Strong electromagnetic interference should also be anticipated during protected building operations.

4.6.4.5 CBR Alarm Pager Procedures

An "All Clear" page was issued to all pager holders at 3:00 PM every day, to confirm that the alert system was fully operational. Pager holders were instructed to call in to the control room if they did not receive their daily page.

4.6.4.6 Radio Communications

DTRA provided Saber Hand Held Radios to supplement communication capabilities. This proved extremely valuable, as there was a great increase in the amount of radio traffic and interference in and around the protected building, rendering ordinary 2-way radios ineffective.

4.6.4.7 Temperature Control in the Protective Envelope

Some zones in the protective envelope experienced high temperatures on warm days during the beginning of operations. This was caused by changes in the number of personnel, lights, computers, etc. that were planned for each zone.

The HVAC system was rebalanced and new sheaves were installed on the Trane units. Some hot zones were cooled by installing new flexible ducts and dampers that feed directly off the main high-pressure duct loop.

This condition should be expected in any future building protection operation, and it is essential to have responsive expert support contractors to restore the balance. Building occupants will attribute heating and cooling problems to the ventilation modifications regardless of whether they actually result from office functional changes.

4.6.4.8 Positive Air Sample Collection

Summa canister systems were installed in the penthouse and programmed to collect background samples. It was planned to have one of the systems set up to collect a sample on demand (in the event of an alarm), but the equipment and controls could not be made operational in time.

The normal use of summa canisters never requires remotely-actuated sampling on demand, and no appropriate control systems were found that did not require modification to accomplish the task. The use of systems that collect a positive air sample should be a priority in future CP programs.

4.6.4.9 Information Briefings

Battelle anticipated a need to work with some of the other people in the protected building. For example, FBI camera operators would have been essential to an investigation of an unverified chemical alarm. Therefore, Battelle prepared several briefings that could be delivered to all those who should be aware of our activities so that they could understand the purpose and methods used to protect the building. Battelle also introduced the control room operators to all those who would possibly be working with them.

5.0 System Maintenance

The following sensors provided information into the Control Room. They were monitored to ensure the building protection system was operating correctly:

Table 17. Parameters Monitored in Control Room

Parameter	No. of Sensors
Total flow from each MCPFS	1 per MCPFS
FFA-1000-200 Pressure drops	10 per MCPFS
Differential pressure – 4th to fifth Floor	1
Differential pressure - fifth to sixth Floor	1
Differential pressure – sixth Floor to Atmosphere	1
Filtered air duct temperature (sixth Floor mechanical room)	1

Parameter	No. of Sensors
Outside air temperature sensor (Met tower)	1
Relative Humidity (Met tower)	1
Barometric Pressure (Met tower)	1
Internal RAID-1 detectors	4
Internal CW Sentry Plus detectors	4
Internal radiation detection systems	4
External CW Sentry Plus detectors	4
External radiation detection systems	4
Internal JBPDS	1
External JBPDS	1
Internal and External CCTV signals	16
Emergency generator remote status panel	17
Fire alarm remote status panel	1

All sensor alarms and anomalies were logged and investigated.

5.1 Filtration System Maintenance

The only regular prescribed maintenance for the filtration system was lubrication of the direct drive fan every three months. High quality lithium-based grease such as Chevron SRI No. 2, Shell Dolium R, or Texaco Premium RB was used to lubricate the fan. Fan lubrication was recorded in each Mil Van and in the Control Room logbook.

5.2 CBR Detection System Maintenance

No regular maintenance of the chemical detectors was planned during the course of this program. All settings and consumables were designed to last long enough to span the planned operational period. In practice, however, it was necessary to manually reset the pump relays on the CW Sentry detectors occasionally. It was also necessary to replace the inlet filters on the RAID-1 detectors once.

The biological agent detectors were monitored and maintained by the JBPDS team. At the beginning of each shift, the JBPDS operators inspected each system and confirmed the operational status. If the JBPDS team leader determined a need to collect a background sample, a single sample was collected at this time.

Every 48 to 72 hours each of the two JBPDS units was taken off-line for approximately one hour for scheduled maintenance. Times were staggered such that both units were not off-line at the same time. The on-site operator notified the sixth Floor Control Room Operator prior to taking a system off-line to assure that the system was not shut down during a window of critical operation. The on-site operator notified the Control Room Operator when the system returned to operational status.

The radiological detectors required no regular maintenance. Bechtel-Nevada representatives were either present in the control room or on call if technical problems had occurred.

5.3 Emergency Power System Maintenance

The EPS installation contractor was responsible for emergency maintenance and repair during the operating interval. No regular scheduled maintenance was necessary. As a diagnostic and confidence check, the emergency generator was programmed to automatically start and run for 20 minutes once each week. A remote instrument panel was installed in the control room on the sixth floor to allow the generator status to be monitored from within the protective envelope.

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5.4 HVAC System Maintenance

The HVAC system was maintained by Colvin Engineering, Atkinson Electronics and Battelle. The Staefa building management system was operated and maintained by Atkinson Electronics. Several minor problems with the HVAC system were addressed and corrected promptly during the operational period.

5.5 Control System Maintenance

The control system was composed of a set of components called "nodes". These nodes provided connectivity to sets of each type of sensor, the main Operator interface, video switching control, and a central "hub" that established the logical "network" and controlled data flow. Each component was located in a rack in the main control room. These nodes were called the Display, Master, Weather, Filtration and Chemical Nodes (see also paragraph 3.7.1). Maintenance for the Control System consisted principally of restarting the nodes after they had been stopped for sensor changes or for any other reason. Restart procedures used for each node are given in the Appendix, along with installation details for diagnostics and data downloading.

5.5.1 Maintenance Lessons Learned

5.5.1.1 Accessibility of Detectors

During the operational period, some of the CBR detectors required attention, but they had been installed in places where they were extremely difficult to access. Priority had been given to keeping the detectors out of sight and protected from unauthorized access.

Four of the exterior detection sites selected were owned by Zion Securities who also owns Social Hall Plaza, which housed the Smart Building Program. This not only made the contracting portion of the external detection much easier than it would have been if the four buildings had four different owners, but it also improved the efficiency of access to the detectors.

Selection of CBR detectors and their installation locations should emphasize their accessibility for maintenance and testing at all hours during operations as well as the security of the detection systems.

6.0 Potential Blast and Shrapnel Protection

Building modifications for protection against the threat of blast, thermal, and shrapnel from an explosive detonation outside the structure were very limited in this program.

If an explosive threat is identified in the TVA for a future building protection program, guidance is provided in the document, "Interim DoD Antiterrorism/Force Protection (AT/FP) Construction Standards," 16 Dec 99 (currently under revision). (available from US Army Corps of Engineers, AATN-CECW-E1, Washington, DC 20314-1000.)

7.0 Decommissioning

7.1 Building Protection Systems

After the Olympic events and post-event activities were finished, DTRA/Battelle coordinated with FBI and Zions Securities officials and completed the disposition of all the equipment associated with the building protection system, including:

- MCPFSs, with pre-filters and boiler system
- Emergency generator system with accessories
- Trane air handling units
- Liebert auxiliary cooling units
- Chemical and radiological detection instruments and accessories
- Control room office equipment
- CCTV monitors and accessories
- UPS units
- Controls system elements, including communications devices

The entire JBPDS bio-detection system had been furnished by the JPO, which was responsible for its removal and disposition.

The main electrical distribution panels for the MCPFS were abandoned in place.

Building modifications associated with the Smart Building program were removed, and the building was restored, essentially to its original condition, in coordination with Zions Securities Corporation, as follows:

- Milvans and support platforms were removed from the roof
- Stairwell security doors were removed
- Decontamination room facilities were removed
- Man traps and airlocks at elevator lobbies were restored to normal office building configurations
- Mechanical rooms were restored to normal office configurations

- HVAC ducting and controls were restored
- Cabling, wiring and vacuum tubing were reviewed and removed or abandoned in place, as appropriate
- Fire alarm modifications were reversed

7.2 Consequence Management Systems

Within sixty days after the conclusion of the Winter Para-Olympics, DTRA/SAIC turned over the following systems to the State of Utah:

- Approximately 85 IBM personal computers with Microsoft Windows operating systems, Microsoft Internet Explorer, Version 5.5 and Adobe Acrobat.
- Two Dell 6300 RAID servers with the Windows NT operating system.
- E Team user licenses (1100 each)
- Two CATS user licenses
- Two server versions of Lotus Domino

Within sixty days after the conclusion of the Winter Para-Olympics, DTRA/SAIC performed the following transition services:

- Two one day E Team training classes to Utah state and local agencies.
- One two day CATS training class to Utah state and local agencies.
- De-installation of all consequence management computer workstations and servers located on the fifth and sixth floors of Social Hall.
- Two one day strategy sessions with Utah emergency management and homeland defense personnel regarding the transition of E Team and CATS from an Olympics-centric system to a State-wide emergency management and homeland defense system.

LIST OF ACRONYMS AND ABBREVIATIONS USED

Acronym	Meaning
AC	Arsine (blood agent)
AC	Alternating current
AHU	Air handling unit
Amp	Ampere
BAWS	Biological Aerosol Warning Sensor
CBR	Chemical, biological, radiological
CCTV	Closed circuit television
cfm	Cubic feet per minute
CIS	Central Information Server
CK	Cyanogen chloride (blood agent)
COTS	Commercial off-the-shelf
CP	Collective protection
CW	Chemical warfare
CWA	Chemical warfare agent
DC	Direct current
DIGS	Data Integrator for Ground Sensors
DIGS/PECOS	Data Integrator for Ground Sensors/Process Equipment Control System
DTRA	Defense Threat Reduction Agency
EDP	Electrical distribution panels
EPS	Emergency Power System
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FTS	Fluid transfer system
GA	Tabun (volatile nerve agent)
GB	Sarin
GD	Soman (volatile nerve agent)
GE,	A volatile nerve agent
GF	A volatile nerve agent
GPS	Global Positioning System
HD	Sulfur mustard (vesicant)
HNC	Nitrogen mustard (vesicant)
HVAC	Heating, ventilation and air conditioning
IMS	Ion mobility spectrometry
IRS	Internal Revenue Service
iwg	Inches, water gauge
JBPDS	Joint Biological Point Detection System
JOC	Joint Operations Center
L	Lewisite (vesicant)
LAN	Local area network
LSM	Local Status Monitor
MBTUH	Million British thermal units per hour
MCPFS	Modular collective protection filtration system

Acronym	Meaning
MIT	Modular Integrated Technologies
NaI	Sodium iodide
NBC	Nuclear, biological, chemical (see CBR)
OCC	Olympic Coordination Center
PECOS	Process Equipment Control System
POC	Point of contact
PREACT™	Planning Response – Evaluation of Airborne Chem/Bio Threats
SAW	Surface acoustic wave
SBCCOM	U.S. Army Soldier, Biological, Chemical Command
SEB	Staphylococcal enterotoxin B
SLC	Salt Lake City
SPEEDS	Special Personnel Event Expedient Decontamination System
STL	Special Technologies Laboratory
TIC(s)	Toxic industrial chemical(s)
TIMMS	Toxic Industrial Material Subscription Service
TVA	Threat and vulnerability assessment
UOPSC	Utah Olympic Public Safety Command
UPS	Uninterruptible power supply
VAV	Variable air volume
VFD	Variable frequency drive
VG	A persistent nerve agent
VM	A persistent nerve agent
VX	A persistent nerve agent

Appendix – Control System Nodes

1.0 Display Node Restart Procedure

For an automatic restart of the Display node process, choose the Microsoft Windows "restart" procedure from the shutdown menu.

For a manual restart, double click the "Shortcut to start_display2.bat" icon on the desktop.

During runtime, the PECOS User Interface display should be visible.

2.0 Display Node Installation Details

Runtime files are located in the following directory tree:

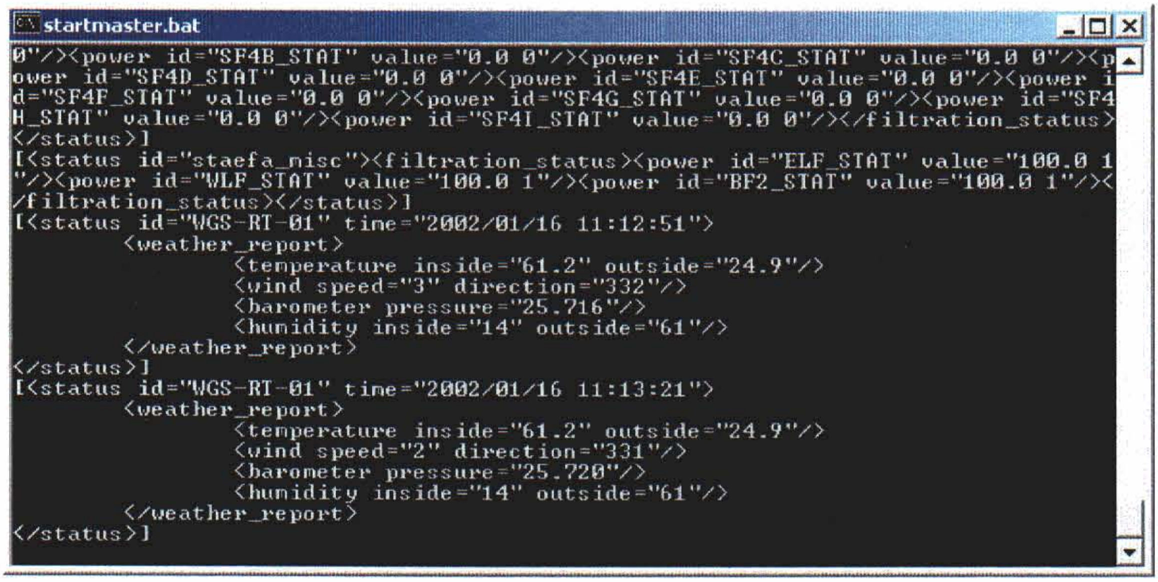
- C:\Pecos\display
  - bin (subdirectory)
  - def (subdirectory)
  - start_display[1,2].bat (startup command used)
- C:\Pecos\display\bin
  - dsp3d.exe (actual runtime executable)
- C:\Pecos\display\def
  - display.def (PECOS display layout configuration file)
  - pecos.def (PECOS node-to-node network configuration file)
  - sensor.def (PECOS sensor-to-node configuration file)
  - camera.def(PECOS camera configuration file)
  - *.map (vector renderings of floor plans used in the display)
  - images (subdirectory) (various images used in the display)

3.0 Master Node Restart Procedure

For an automatic restart of the Master node process, choose the Microsoft Windows "restart" procedure from the shutdown menu.

For a manual restart, double click the "startmaster.bat" icon on the desktop.

During runtime, a DOS window is displayed with a scrolling log of traffic being received or sent.



4.0 Master Node Installation Details

Runtime files are located in the following directory tree:

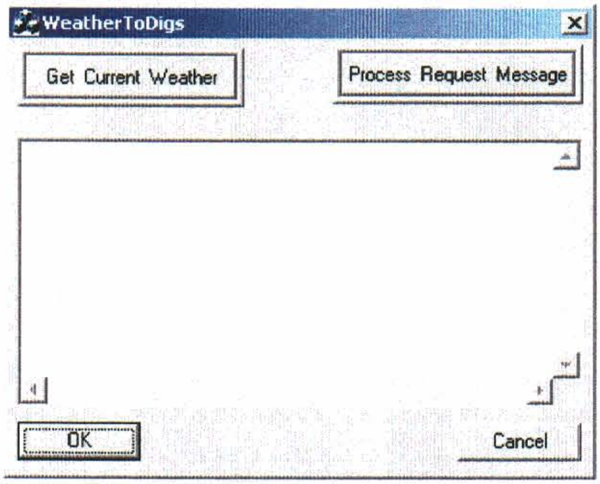
- C:\Pecos
  - bin (subdirectory)
  - def (subdirectory)
  - startmaster.bat (startup command used)
  - master.exe (actual runtime executable)
- - C:\Pecos \bin
  - empty
- - C:\Pecos\ def
  - pecos.def (PECOS node-to-node network configuration file)
  - sensor.def (PECOS sensor-to-node configuration file)
  - camera.def(PECOS camera configuration file)

5.0 Weather Node Restart Procedure

For an automatic restart of the Weather node process, simply choose the Microsoft Windows "restart" procedure from the shutdown menu.

For a manual restart, double click the "Shortcut to WeatherToDigs.exe" icon on the desktop. Note that currently manual restart is not supported.

During runtime, the following window will appear. Note: There is no need to press any of the buttons for runtime operations. All requests for data come through the main PECOS Displays.



6.0 Weather Node Installation Details

Runtime files are located in the following directory tree:

- C:\weather
  - Weather Connection Configuration.exe (PECOS connectivity UI)
  - WeatherStationConfig.exe (sensor connectivity UI)
  - weatherlink.dll (sensor connectivity library)
  - Weather_v1.mdb (runtime data logging)
  - WeatherToDigs.exe (actual runtime executable)

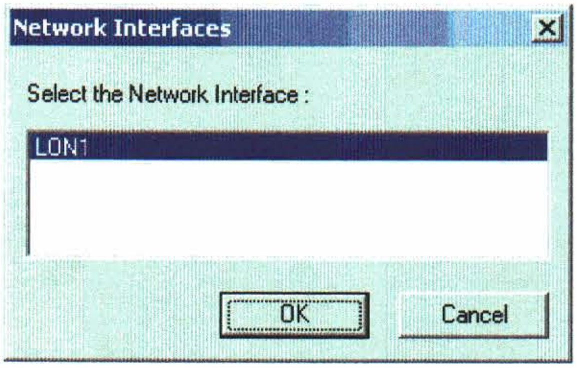
7.0 Filtration Node Restart Procedure

For an automatic restart of the Filtration node processes, simply choose the Microsoft Windows "restart" procedure from the shutdown menu. Three processes will be restarted and two of them require manual inputs from the Operator (see below).

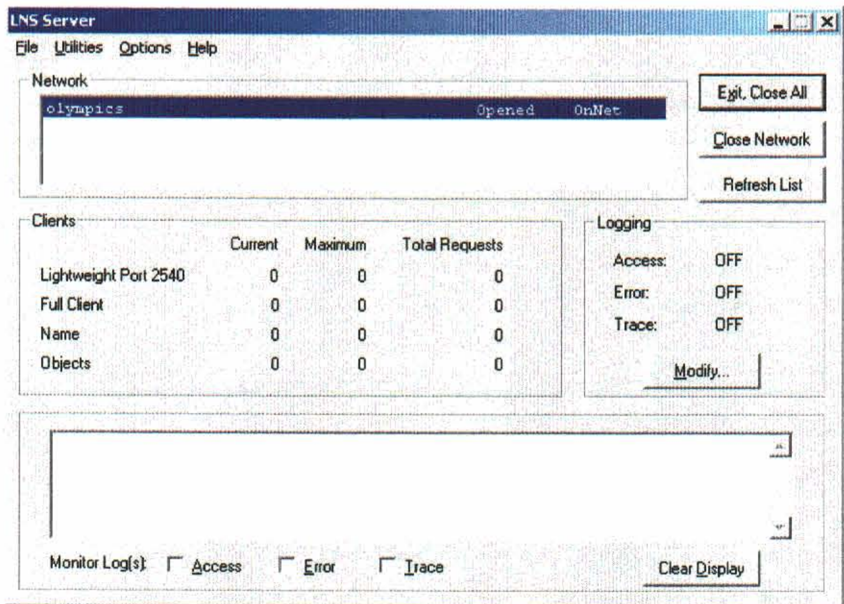
For a manual restart, all three processes must be started. First double click the "LNS Server" icon (see Steps 1a – 1b below), then click the "[Long]LonVan.exe" icon (see Steps 2a – 2b below), and finally click the "filtration.bat" (see Step 3) icon on the desktop. *Note that the first two require manual inputs from the Operator (see below).*

During startup and runtime, the following windows will appear.

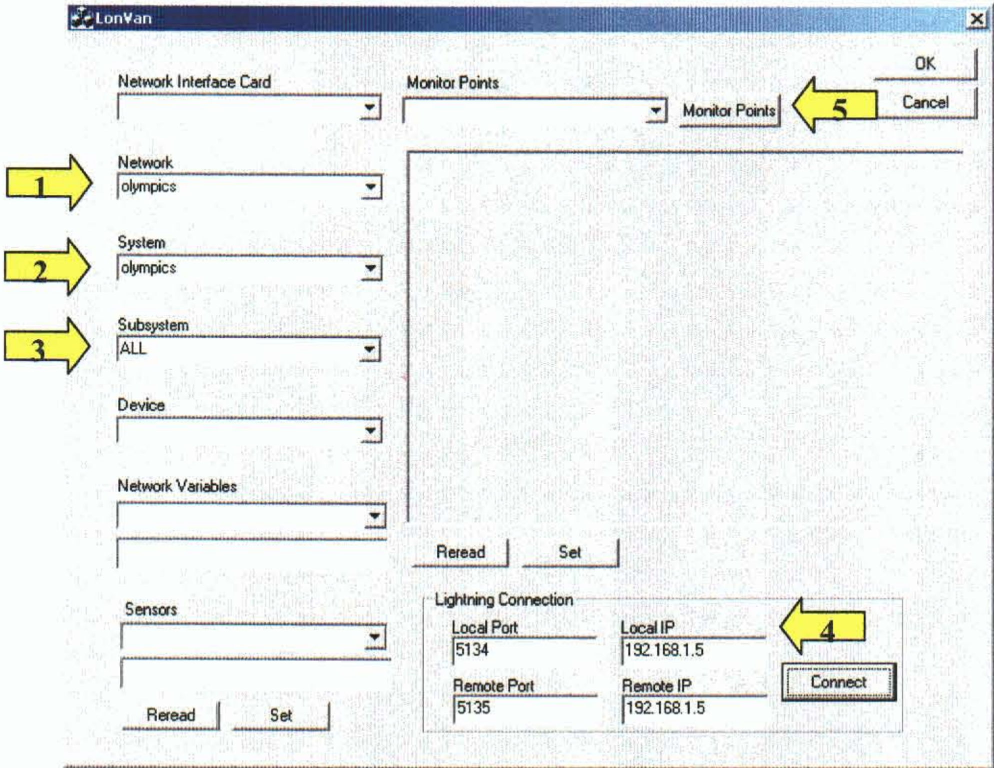
Step1a. LNS Server: The window below appears first. Highlight the "LON1" selection as shown and press the "OK" button.



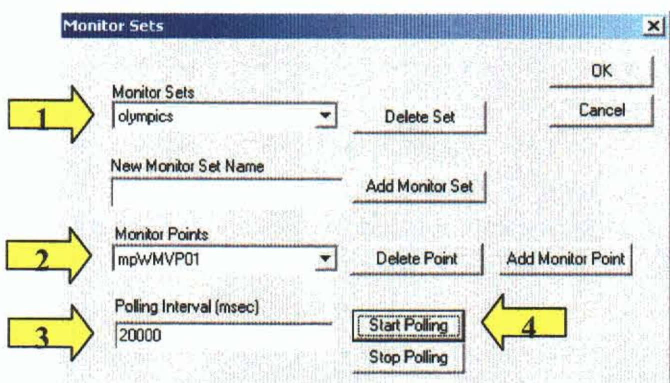
Step 1b. The window below should now appear. No other action is required for this process. Now proceed to Step 2.



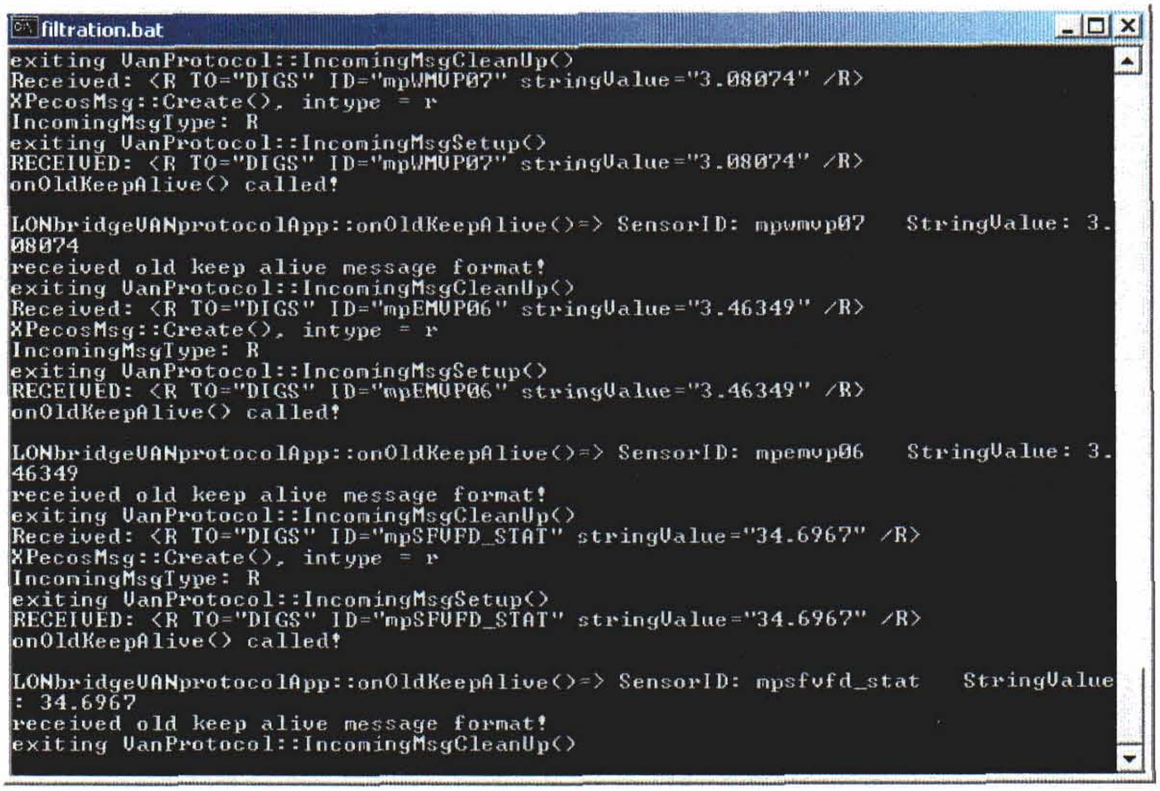
Step 2a. [Long]LonVan: The window below appears first. There are five sub-steps to this window. (1) First, select the "olympics" item from the Network menu. (2) Next, select the "olympics" item from the System menu. (3) Then, select the "All" item from the Subsystem menu. (4) Lastly, enter in the values indicated under the Lighting Connection section located in the bottom right-hand portion of the screen and press the "Connect" button. The screen should appear as it does below. (5) To proceed to the next step (2b), press the "Monitor Points" button.



Step 2b. Pressing the "Monitor Points" button brings up the window below. There are four sub-steps to this window. (1) First, select the "Olympics" item from the Monitor Sets menu. (2) Next, select the "mpWMVP01" item from the Monitor Points menu. (3) Then, enter the number of milliseconds to poll the filtration sensors (this example shows a 20,000-msecs or 20-second poll rate). (4) Lastly, press the "Start Polling" button. Data is now being read from the various filtration sensors via the Lon-net. Proceed to Step 3.



Step 3. filtration: This process does not require any manual inputs at startup time. During runtime, a DOS window is displayed with a scrolling log of traffic being received or sent.



8.0 Filtration Node Installation Details

Runtime files are located in the following directory tree:

- C:\Pecos
  - filtration.bat (startup command used)
    Note: the "filtration.bat" shortcut on the desktop points to this file
  - FiltrationStatus.exe (actual runtime executable)
  - [Long]LonVan.exe (actual runtime executable)
    Note: the "[Long]LonVan.exe" shortcut on the desktop points to this file
  - sensors.lon (Lon configuration file)
- C:\LonWorks\bin
  - lcaserv.exe (actual runtime executable)
    Note: the "LNS Server" shortcut on the desktop points to this file
- C:\LonWorks\bin\LonMaker (used for alternate device status display only)
  - lonmaker.exe (actual runtime executable)
    Note: the "LonMaker for Windows" shortcut on the desktop points to this file

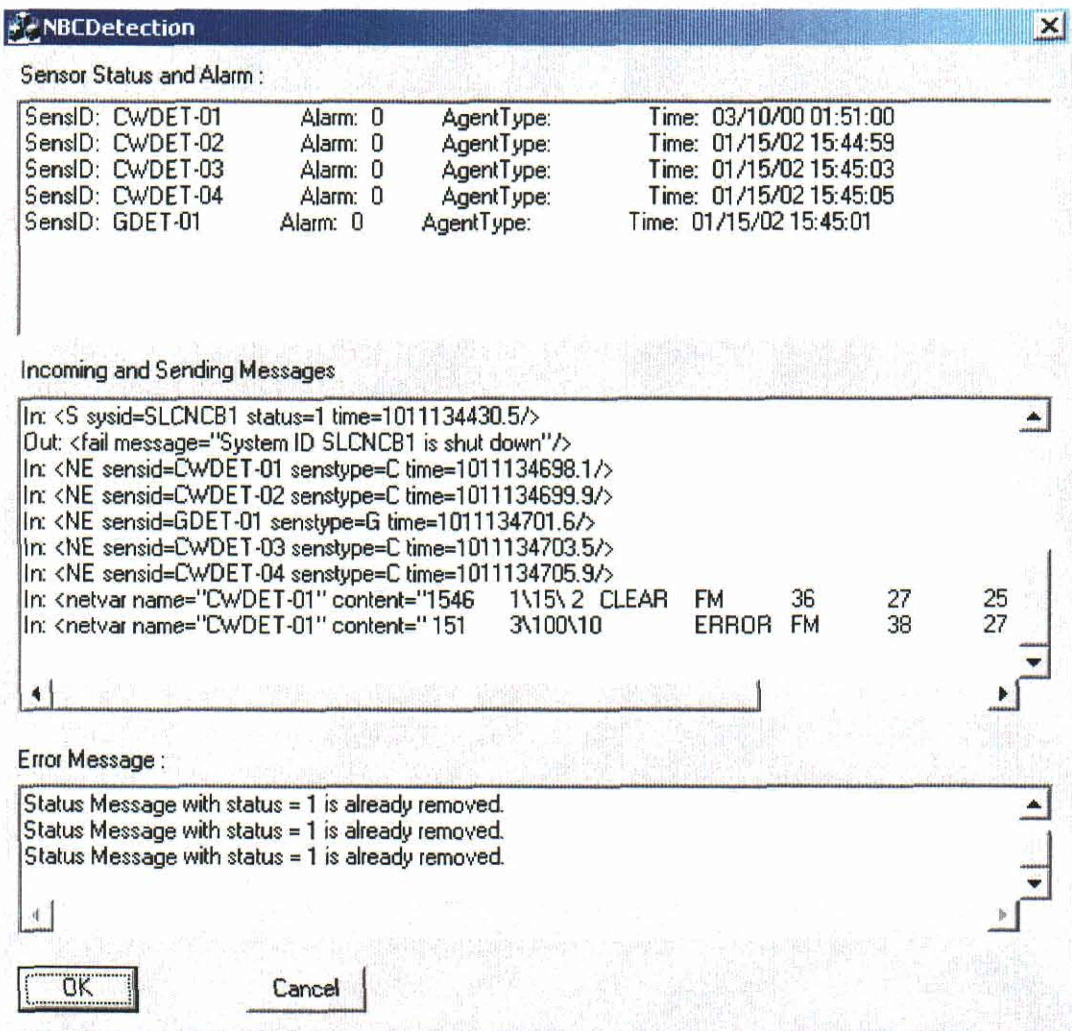
9.0 Chemical Node Restart Procedure

Note: This node uses the "LNS Server" process started for the Filtration node. Therefore it must be started after the Filtration node is up and running.

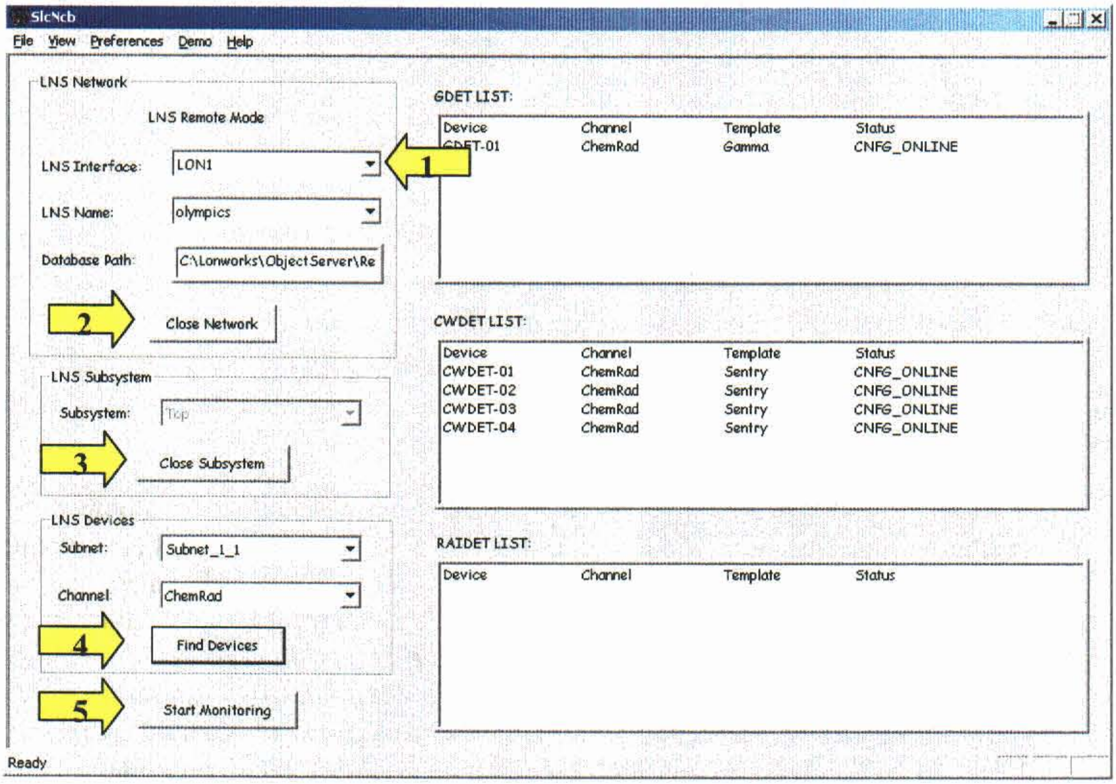
For an automatic restart of the Chemrad node processes, simply choose the Microsoft Windows "restart" procedure from the shutdown menu. Two processes will be restarted and one of them requires manual inputs from the Operator (see below).

For a manual restart, the two processes must be started. First, double click the "NBC Monitor" icon (see Step 1 below), and then click the "SlcNcb" icon (see Steps 2a – 2e below). Note that the second one requires manual inputs from the Operator (see below).

During startup and runtime, the following windows will appear. Step1. NBC Monitor: The window below will appear. Note: There is no need to press any of the buttons for runtime operations. During runtime, the various windows will display messages being sent and received but may be empty during an initial startup. Once this window is up, proceed to Step 2.



Step 2. SlcNcb: The window below appears first. There are five sub-steps to this window. (1) First, select the "LON1" item (in the LNS Network group) from the LNS Interface menu. This will cause the other items LNS Name and Database Path to fill in with defaults. (2) Next, press the "Open Network" button (which will then change to "Close Network" as shown). (3) When step 2 finishes, the Subsystem menu (in the LNS Subsystem group) will fill in with the appropriate default, so just press the "Open Subsystem" button which will then change to "Close Subsystem" as shown). (4) When step 3 finishes, the Subnet and Channel items (in the LNS Devices group) will fill in with the appropriate defaults, so just press the "Find Devices" button. The screen should appear as it does below. (5) To complete startup press the "Start Monitoring" button. You should now notice updates in the NBC Monitor process windows from step 1 above.



10.0 Chemical Node Installation Details

Runtime files are located in the following directory tree:

- \- C:\NCB_Ensco
  - NBC Connection Configuration.exe (PECOS connectivity UI)
  - NBC2k_revison.mdb (runtime data logging)
  - NBCMonitor.exe (actual runtime executable)
    Note: *the "NBC Monitor" shortcut on the desktop points to this file*
- \- C:\Program Files\SlcNcb
  - SlcNcb.exe (actual runtime executable)

DEPARTMENT OF DEFENSE

DEFENSE TECHNICAL
INFORMATION CENTER
8725 JOHN J. KINGMAN ROAD,
SUITE 0944
FT. BELVOIR, VA 22060-6201
2 CYS ATTN: DTIC/OCA

DEFENSE THREAT REDUCTION
AGENCY
8725 JOHN J. KINGMAN ROAD
STOP 6201
FT. BELVOIR, VA 22060-6218
2 CYS ATTN: SED/R. KEHLET

DEPARTMENT OF DEFENSE CONTRACTORS

ITT INDUSTRIES
ITT SYSTEMS CORPORATION
1680 TEXAS STREET, SE
KIRTLAND AFB, NM 87117-5669
2 CYS ATTN: DTRIAC
ATTN: DARE

NORTHROP GRUMMAN
CORPORATION
DEFENSE ENTERPRISE
SOLUTIONS
6940 SOUTH KINGS HIGHWAY
ALEXANDRIA, VA 22310
ATTN: CHARLES ALLEN